595.7
M76
v.26
cop.2

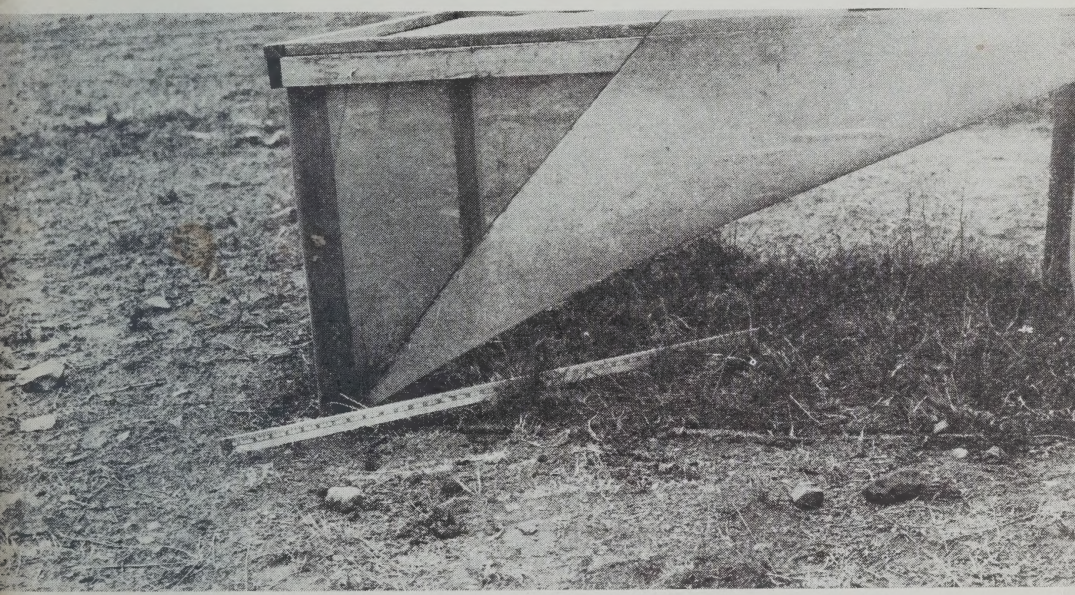
ETIN NO. 333 JANUARY, 1937

Montana Insect Pests for 1935 and 1936

The Twenty-Sixth Report of the State Entomologist of Montana

BY

A. L. STRAND, STATE ENTOMOLOGIST



Grasshopper damage to range grasses. The grass beneath the cage was protected from grasshoppers; the grass outside the cage, protected from livestock by a tight fence, was completely destroyed by grasshoppers. (Courtesy of United States Bureau of Entomology and Plant Quarantine.)

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

Digitized by the Internet Archive
in 2025 with funding from
University of Illinois Urbana-Champaign Alternates

https://archive.org/details/montanainsectpes2629mont

LETTER OF TRANSMITTAL

Bozeman, Montana,
January 1, 1937

To His Excellency,
Governor Roy E. Ayers,
Helena, Montana.

My Dear Sir:

I present herewith the 26th report of the State Entomologist of Montana.

Injurious insects during the biennium just closed were never exceeded in number and variety, we believe, during any like period in the agricultural history of the state. In addition to the continuance of grasshoppers and Mormon crickets as major crop pests, and a recurrence of the pale western cutworm which destroyed several thousand acres of wheat, many other insect species, which were either new as pests in the state, or made their appearance in great numbers after several years of inactivity, attacked various crops with demoniacal fury. The abundance of some of our worst insects is directly related to a lack of precipitation. Dry years are unfavorable to fungus and bacterial parasites which normally keep many of these pests in check. The drought forced more insects onto irrigated lands and it was in the protection of irrigated crops that the greatest saving from insect control work resulted in 1935 and 1936.

One of the chief functions of the State Entomologist in recent years has been to direct within the state insect campaigns supported in part by the federal government. If the proposal now before the congress of the United States, for a permanent fund of five million dollars to be used in emergencies against insects of regional importance, receives favorable action, even more extensive duties will fall upon this office.

We wish to call your attention particularly to the problem of grasshopper damage to range grasses as presented in this report and to the need for greater state support for research and control work in order to gain the fullest advantage from federal funds appropriated for the control of our major insect pests.

Respectfully yours,

A. L. STRAND,
State Entomologist

TABLE OF CONTENTS

Page

The control of insect pests in Montana 5
- Grasshoppers on cultivated lands in 1935 6
- Grasshoppers in relation to cultivated crops in 1936 7
- Grasshoppers in relation to the range, 1934-1936 9
- Losses from grasshoppers and savings which have been effected..... 16
- The grasshopper situation for 1937 17
- The Mormon cricket situation, 1937-1937 18
- Financial support for grasshopper and cricket control in Montana..... 21

Important insects of the years 1935-1936 25
- The pale western cutworm 25
- Say's plant bug 25
- The beet webworm 26
- Blister beetles 28
- The false chinch bug 28
- Fruit insects 29
- Small fruit insects 33
- Forest tent caterpillar 35
- Virginia creeper leafhopper 36
- Alpine rock crawler 38

Twenty-Sixth Report of the State Entomologist

THE CONTROL OF INSECT PESTS IN MONTANA

Next to dry weather and the lack of irrigation water, insects constitute the greatest hazard to the production of agricultural crops in Montana. The control of insect pests is most economically accomplished when there is close accord between control activities and the research work which may be in progress on the insects involved. A library containing the voluminous standard works on entomology as well as the current scientific literature is required. A collection of insects, named, catalogued, and as nearly as possible giving complete coverage of the state both as to uncommon and economic species, is likewise an essential. In other words, the suppression of insect pests must be based on all available information and constantly improved by investigation. For these reasons the law creating the Office of State Entomologist, passed in 1903, designated the entomologist of Montana State College and Agricultural Experiment Station as the State Entomologist. By so doing needless duplication and unnecessary expense were avoided and at the same time the best possible service to the agricultural interests of the state was assured.

The State Entomologist, as evident therefore, has his regular duties in the College and Experiment Station. No part of his salary comes from the State Entomologist Fund.* His duty is to direct the insect control work which, as shown above, is intimately tied up with the investigation of insects. Consequently he must have the necessary assistants to properly carry out the objectives of the State Entomologist law. In years past the appropriations for this work have at times been too small to employ any help whatever and the work has suffered accordingly. The twenty-fourth session of the Montana Legislature increased the appropriation sufficiently to allow the em-

*The work of the State Entomologist should not be confused with that of the State Board of Entomology. Appropriations to the State Entomologist Fund are used for the suppression of insect pests of agricultural crops. The Board of Entomology is concerned with ticks and insects responsible for the transmission of various diseases to man and animals.

ployment of one full-time assistant, Dr. H. B. Mills, who has served as Assistant State Entomologist since July 1, 1935.

The State Entomologist cooperates closely with the Montana Agricultural Extension Service, carrying out much of his work through the county agents. The two agencies have shared with the United States Department of Agriculture the expense of the annual grasshopper survey, the accumulation of data on which has resulted in obtaining much needed federal aid on the control of migratory insects, and all phases of the general problem of insect control. The Agricultural Extension Service does not employ an entomologist, which function is delegated to the State Entomologist.

In the following pages will be found brief discussions of the most important insect problems in Montana during the past two years, the financial saving which has been made through insect control, and a statement of the needs and plans for future work.

GRASSHOPPERS ON CULTIVATED LANDS IN 1935

Severe losses from grasshoppers occurred in 1935. Whereas in 1934 the heaviest infestations were found on nonirrigated lands in northern and north-central Montana, during 1935 the severe infestations were on or near irrigated land along the Yellowstone river. This shift in grasshopper populations was not indicated by the egg survey in the fall of 1934. Park and Sweetgrass counties were properly warned of the impending danger, but the estimates for Stillwater, Yellowstone, Treasure, Big Horn, Rosebud, and Custer counties were entirely too low and gave the farmers a feeling of false security. This undue faith in the survey prediction was unfortunately strengthened by the delayed hatching of the grasshoppers. Until late June and early July little hatching had taken place and farmers, who looked over their fields up to that time, could see little evidence of the trouble which was coming. It had been estimated that about 331 tons of poisoned bait would be needed in the eight counties noted above; actually over 600 tons were used, or over a third of the total for the entire state. See table 6.

Even though poisoning operations were delayed, thousands of acres of irrigated crops were saved by strenuous campaigns beginning about the first week in July. Through the coopera-

tion of the Agricultural Extension Service and this office, twenty-one cars of federal bait were shipped into the Yellowstone Valley in addition to several cars of new bran and arsenic laid down there early in the season, in exchange for an equal amount of bait shipped from eastern Montana points into North Dakota. Freight on the July shipments was paid by the counties but as a special tariff on grasshopper bait and bait materials had been obtained early in the season, the actual cost per ton of bait received was very low.

GRASSHOPPERS IN RELATION TO CULTIVATED CROPS IN 1936

Thirty-six counties engaged in grasshopper control in 1936. Each of fifteen counties used more than 50 tons of poisoned bait, dry basis, and nine used a total of 100 tons each or more. One county, Yellowstone, put out 754 tons. Altogether, farmers, county agents, and county commissioners feel that the campaign was one of the most successful ever carried out in the state although it did not approach in extent and intensity the control work on grasshoppers done in 1934. As will be seen from table 1, over 3,000 tons of dry bait were distributed or enough to give one treatment to 600,000 acres. The actual amount used by farmers in protecting crops on cultivated land was probably more than is indicated by the record given. Much of the sawdust used in diluting the usual bait ingredients was unaccounted for and many tons of old bait stored on farms came into use without appearing in county totals. The total bait distributed was probably close to 3,800 tons.

The chief sources of bait were from county and private funds and from the supply of old federal bait left over from the previous two years. The Works Progress Administration furnished 328 tons of bran in 14 counties. The remainder, or 402.5 tons came from a special appropriation passed by congress in the latter part of June and administered by the United States Bureau of Entomology and Plant Quarantine. The new federal bait and WPA supplies came late in the season so the above figures do not represent the total amounts received from those sources but only the amounts used. Of the 840 tons of bran in storage for the expected 1937 outbreak of grasshoppers, a large part came from WPA and 97.5 tons from the direct

TABLE 1.—GRASSHOPPER BAIT USED IN MONTANA IN 1936

County	Old fed. bait	New fed. bait	WPA bait	County and private bait	Total
	Tons	Tons	Tons	Tons	Tons
Beaverhead	—	—	—	25.5	25.5
Big Horn	5.0	40.0	43.0	100.0	188.0
Blaine	15.0	—	—	—	15.0
Carbon	—	20.0	20.0	200.0	240.0
Cascade	100.0	—	—	—	100.0
Chouteau	20.0	—	—	—	20.0
Custer—Powder River	24.0	—	—	—	24.0
Daniels	2.0	—	—	—	2.0
Dawson	4.0	—	—	—	4.0
Fallon-Carter	.8	—	—	—	.8
Fergus	70.0	—	—	10.0	80.0
Flathead	—	—	—	0.15	0.15
Gallatin	20.0	20.0	20.0	24.0	84.0
Garfield-Petroleum	5.0	—	15.0	5.0	25.0
Glacier	20.0	—	—	—	20.0
Hill	26.0	—	—	—	26.0
Judith Basin	30.0	—	5.0	—	35.0
Lake	1.4	—	—	—	1.4
Lewis and Clark—Broadwater	17.0	—	—	7.9	24.9
Madison—Jefferson	45.0	—	—	12.0	57.0
Missoula	—	—	—	.1	.1
Musselshell—Golden Valley—	0.3	20.0	5.0	—	25.3
Park	8.0	—	24.0	14.5	46.5
Phillips	20.0	—	3.0	2.5	25.5
Pondera	156.0	—	10.0	1.5	167.5
Prairie	7.0	—	—	—	7.0
Richland	30.0	—	—	—	30.0
Roosevelt	40.0	37.0	—	—	77.0
Rosebud	45.0	20.0	30.0	25.0	120.0
Sanders	3.5	—	—	—	3.5
Sheridan	60.0	—	—	5.0	65.0
Stillwater	10.0	6.5	18.0	25.5	60.0
Sweet Grass	6.0	80.0	80.0	214.0	380.0
Teton	130.0	20.0	40.0	—	190.0
Toole	100.0	—	—	—	100.0
Valley	14.5	—	—	—	14.5
Wheatland	—	—	15.0	—	15.0
Wibaux	—	10.0	—	—	10.0
Yellowstone	—	129.0	—	625.0	754.0
Totals	1035.5	402.5	328.0	1297.65	*3063.65

*Estimates on sawdust used (750 tons) bring this total up to 3813.65 tons dry bait used for 1936.

federal appropriation. The remainder is bran purchased by counties under the insect pest law. See table 2.

A very great part of all the poisoned bait used in 1936 went to protect irrigated crops. In many localities over the state but particularly in the Yellowstone Valley large acreages would have been completely destroyed by grasshoppers had it not been for the intensive control programs which were organized against them.

TABLE 2.—GRASSHOPPER BAIT AND BAIT MATERIALS ON HAND

County	Mixed bait	Bran	Sodium arsenite*	Crude arsenic	Molasses
	Tons	Tons	Gallons	Pounds	Gallons
Beaverhead	—	22.5	400	—	—
Big Horn	2.0	50.0	300	2000	—
Blaine	—	20.0	—	500	—
Carbon	—	60.0	44	—	—
Cascade	—	—	500	—	—
Chouteau	—	20.0	—	2800	5
Custer—Powder River	1.0	60.0	—	775	275
Daniels	11.0	—	—	2700	—
Dawson	36.0	—	—	—	—
Fallon—Carter	—	—	—	—	—
Fergus	5.0	75.0	350	2000	200
Flathead	5.0	—	—	—	—
Gallatin	—	30.0	125	150	—
Garfield—Petroleum	—	20.0	200	—	50
Glacier	8.0	—	—	2000	1000
Hill	15.0	15.0	—	19000	—
Judith Basin	15.0	15.0	—	1200	—
Lake	—	—	—	—	—
Lewis and Clark—Broadwater	3.0	—	—	2100	—
Madison—Jefferson	22.0	—	220	800	25
Missoula	—	—	—	—	—
Musselshell—Golden Valley	—	15.0	—	800	150
Park	—	55.0	50	—	—
Phillips	10.0	57.0	—	500	—
Pondera	65.0	42.0	—	—	—
Prairie	15.5	—	—	—	—
Richland	30.0	60.0	200	1500	—
Roosevelt	3.0	—	—	2500	—
Rosebud	—	15.0	200	—	1000
Sanders	20.5	—	—	600	—
Sheridan	5.0	60.0	—	—	—
Stillwater	—	26.0	200	500	—
Sweet Grass	—	18.0	—	—	—
Teton	12.0	22.0	300	8000	—
Toole	40.0	—	—	6000	—
Valley	25.5	—	—	—	—
Wheatland	—	45.0	200	1200	—
Wibaux	30.0	—	—	—	—
Yellowstone	20.0	37.5	200	1272	—
Totals	399.5	840.0	3489	58,897	2805

*Liquid sodium arsenite on basis of "4 lb. material"

GRASSHOPPERS IN RELATION TO THE RANGE, 1934-1936

The most serious insect problem in Montana at the present time is to find and demonstrate a way of preventing the destruction of range forage plants by grasshoppers. This damage was severe in 1934 but has become even worse the past two seasons. In those three years the total loss on the range has been set at $1,750,000. (See table 4). This figure is probably far too low; it is based on an estimated damage of approximately 16 to

20 per cent of the range in central and eastern Montana and a value of 10 cents per acre for the grass destroyed.

Drought has been, of course, an important factor in the depletion of the range, but any doubt concerning the part that is played by grasshoppers can be dispelled by an examination of the picture on the cover page of this report. Grass developed in spite of the drought but was eaten down to the ground by hordes of grasshoppers. If we should include the financial losses incident to the forced movement or sale of livestock directly connected with grasshopper damage to range grasses, to say nothing of the loss to cultivated crops by the migrations into them of range species, the total loss encountered would be at least twice that indicated above, or approximately $3,500,000. When we consider that the direction of our agricultural development has turned strongly toward the improvement and better use of our grazing resources, this problem assumes no small importance as a factor contributing to the future prosperity of the state.

The problem is not a new one; it has just presented itself in a new light. When we are successful in preventing by means of poisoned bait about one-half the loss that would otherwise occur to our cultivated crops, (actually we could do far better) it seems almost absurd that nothing so far has been done to prevent at least a part of the heavy losses to our range. In the late 1870's and early 80's, again from 1900 to 1904, and to a lesser extent in the early 1920's grasshoppers did tremendous damage to our grass lands. In the past, with the return of years of greater precipitation, the grass revived while at the same time conditions were unfavorable to grasshopper development and they deceased to unimportant numbers. The same will no doubt happen again if we do nothing at all. But why should we take that viewpoint in regard to the range and not in regard to other valuable crops? The reason is that it has never been demonstrated in this country that range grasshoppers can be controlled on a sound economic basis.

There are two possible approaches to the solution of the problem: (1) Await the return of years of higher precipitation with conditions unfavorable to grasshopper development. When natural causes have depleted their numbers then keep them down by the diligent use of poison in areas where outbreaks

seem to make their start. (2) By use of a less expensive poisoned bait during the development of an outbreak and even at its height.

The Prevention Idea in Range Grasshopper Control

There is much to be said in favor of this method but also a few adverse points to consider in its possible application to Montana conditions. The most economic way of handling all insect-control problems is to apply the remedy, whatever it may be, before the insects have reached the outbreak stage. That is the cheapest and in many cases the only feasible line of attack. This approach to the range-grasshopper problem has been tried and proved successful in British Columbia where very extensive range areas are under the control of relatively few individuals. There the warrior grasshopper is the dominant species. This 'hopper has two rather conspicuous characteristics. It is very

TABLE 3.—TOTAL NUMBER OF GRASSHOPPERS BY SPECIES AND FREQUENCY OF OCCURRENCE ON RANGE AND IN CROP SUMMARIZED FROM 30 COLLECTIONS, JULY, 1936

Scientific name	Common name if any	Total collected		Frequency of occurrence	
		Range	Crop	Range	Crop
Melanoplus mexicanus	Lesser Migratory	336	430	16	12
Melanoplus bivittatus	Two-striped	1	18	1	6
Melanoplus packardi	Packard's	59	35	14	7
Melanoplus occidentalis	———	11	4	3	2
Melanoplus infantalis	———	107	7	15	3
Melanoplus confusus	———	2	0	2	0
Melanoplus femur-rubrum	Red-Legged	5	0	3	1
Melanoplus bowditchi	———	1	0	1	0
Camnula pellucida	Warrior	63	172	9	5
Dissosteira carolina	Carolina	10	6	5	4
Aulocara elliotti	Big-Headed	440	178	19	9
Metator pardalinus	———	25	15	8	7
Aeoloplus turnbulli	———	72	15	7	5
Orphuella pelidna	———	0	1	0	1
Hadrotettix trifasciatus	———	4	1	3	1
Ageneotettix deorum	———	165	9	16	2
Bruneria brunnea	———	2	6	2	1
Derotmema haydeni	———	8	6	4	1
Amphitornus coloradus	———	35	4	7	2
Cordillacris crenulata	———	24	0	6	0
Trachyrhachis kiowa	———	27	1	12	1
Hesperotettix viridis	———	9	0	4	0
Aeropedellus clavatus	———	4	0	1	0
Drepanopterna femoratum	———	19	0	4	0
Trimerotropis campestris	———	5	0	3	0
Trimerotropis laticincta	———	0	3	0	1
Trimerotropis agrestis	———	0	1	0	1
Cordillacris occipitalis	———	2	0	2	0

easy to poison, and it lays its eggs in very definite types of terrain so that in the spring the young 'hoppers are concentrated in relatively small areas. The importance of these two things can be readily appreciated in any program where the object is the prevention of outbreaks.

Now in Montana there is more than one important species on our range; in fact a dozen different species must be considered and at least three or four are of primary concern. Last summer thirty different collections of grasshoppers were made through central, north-central, and eastern Montana with the idea of showing the relative distribution of species on the range and in near-by crops. The results are shown in table 3. These collections were made in July before the great seasonal dispersion and migration of grasshoppers took place. It will be seen that out of the twenty-five different kinds of grasshoppers collected on range land, five or six were not only very abundant but were taken in many different places. The most important ones are the Big-headed grasshopper *(Aulocara elliotti)* and the Lesser Migratory grasshopper *(Melanoplus mexicanus)*. These are surely the dominant ones and are shown in figures 1 and 2. At different times and in different places several other species would doubtless be important factors in range destruction. Possibly the Warrior grasshopper *(Camnula pellucida)* should rank third over the state in general, although superceded in these particular collections by two other species. With such a ranking the three important range grasshoppers are also very important to cultivated crops, although they are not the only ones.

In relation to these data it is worth while to note that R. A. Cooley in the First Report of the State Entomologist, December, 1903, wrote as follows:

> In our various trips into the worst affected regions we found a fairly uniform state of affairs throughout. On the range two or three species, taken together, constitute a large proportion of the total number, though in restricted localities one or another species besides these was more abundant. The three most common species on the range were the Big-headed locust *(Aulocara elliotti)*, the Lesser Migratory locust *(Melanoplus atlanis)*, and the Yellow-winged or Warrior locust *(Camnula pellucida)*. In point of abundance the Big-headed grasshopper was the leading species of the three. The Lesser-Migratory locust was second in importance. It prefers the drier uplands to the irrigated valleys, but in many cases it was found in great abundance in grain fields, particularly on the benches and in non-irrigated

fields. The Yellow-winged, or Warrior, locust is more local in its distribution, often occurring in immense numbers in restricted localities and at times becoming very injurious to grasses and grains.

Figure 1.—The big-headed grasshopper *(Aulocara elliotti)*, the dominant species on the range in Montana.

It will be seen by comparing Professor Cooley's remarks with table 3 that conditions today are much the same as in 1903. We have now and probably always have had a more complicated situation on our range than apparently obtains at the present time in British Columbia. It should be remembered as well that our range has been the breeding ground from whence have come some of the great historical grasshopper outbreaks. It made up a large part of the primary breeding territory of the notorious Rocky Mountain Migratory locust which laid waste a large part of the middle west some sixty years ago. We are forced to assume that for generations past this territory has been very favorable at times, and not infrequently, to the development of grasshoppers which in number and variety have been equalled by few other areas in the world.

In order to successfully prosecute a program built around the idea of the *prevention of grasshopper outbreaks on the range* the following factors important and necessary thereto may be summarized as follows:

1. The program would have to include cultivated land as

well as range land since the two most important species on the range are also very important on cultivated lands.

2. The program would prove difficult in proportion to the degree in which various range species scatter their egg pods. The Lesser Migratory grasshopper and many other kinds do not concentrate their egg pods as does the Warrior.

3. Almost an ideal spirit of cooperation would be required among many different groups: ranchers, farmers, governmental agencies such as the Forest Service, the Indian Service, the Taylor Grazing Units, the Resettlement Administration, the state and counties in relation to lands under their permanent or temporary control, nonresident land owners, etc.

4. Some kind of a governmental subsidy to make the program work for not the least difficulty would be in getting grasshoppers poisoned at the times when range or crop damage was not imminent.

Figure 2.—The lesser-migratory grasshopper *(Melanoplus mexicanus)*, the second most important species on the range and the most destructive species to cultivated crops in Montana.

5. The organization of the control work to cover over 30,000,000 acres of range land in central and eastern Montana and 20,000,000 acres in farms. In addition excellent cooperation with other states and the Dominion of Canada would be required on account of the migration of various species of grasshoppers at least during the height of an outbreak.

6. A broader and more intensive program of grasshopper research than is being supported at the present time.*

Direct Offensive Against Range Grasshoppers

According to this method of approach we would attempt the control of range grasshoppers by an extensive campaign of poisoning on the range. During the worst years five million acres or more would have to be treated, although there are times even in great outbreak years when the 'hoppers seem to congregate in low places where the feed is greener, making it possible to get considerable control by treating a smaller percentage of the entire area. With our present bait formula, a straight poisoning campaign, in which a large part of affected range would be treated, does not appear to be economically sound. The cost of bait alone would be about 10 cents per acre which is about the rent value of the grass saved on good range if perfect control were obtained. Let us look for a moment at the economics of poisoning just one-sixth of the range land east of the continental divide in Montana. This woud be approximately five million acres. Provided the bait could be cheapened to half the cost of that now in general use the expense would be $312,500. As there is probably not man power on our ranches sufficient to take care of the spreading of 25,000 tons of bait, the cost of distribution would enter into the total cost of the operation. There are three possible ways by which the bait could be distributed: by hand from light trucks or buckboards, by mechanical spreaders, or by airplanes. Accordingly, the cost for one application of poisoned bait to five million acres, counting one dollar an hour for hand spreading (two men), one and one-half dollars per hour for the operation of a mechanical

*The Montana Agricultural Experiment Station is no longer engaged in investigation of grasshoppers. In 1930 when the laboratory of the U. S. Bureau of Entomology and Plant Quarantine was established on the campus at Montana State College with Dr. J. R. Parker (formerly with the Montana Agricultural Experiment Station) in charge, an agreement was entered into under which research work on grasshoppers is to be done by the federal laboratory and the control of grasshoppers by the State Entomologist's office.

spreader, and twelve dollars per hour for an airplane, would be about as follows:

Method of spreading	Rate acres per hour	Labor time hours	Cost of spreading	Cost of bait	Total cost
Hand	8	$625,000	$625,000	$312,500	$937,500
Mech. Spreader	25	200,000	300,000	312,500	512,500
Airplane	100	50,000	600,000	312,500	912,500

It is extremely doubtful if enough airplanes to do the job within a reasonable length of time could be found in the country. Furthermore even at twelve dollars per hour, which is a very low rate for airplane hire, the cost is excessive. The airplane method is all very well for dusting a few acres of high-priced crops in California, but for grasshopper control it appears very impractical. Even more impossible and expensive would be hand spreading. On the contrary the use of mechanical spreaders, made from the rear ends of old automobiles, is within the bounds of reason. Two thousand such mechanical spreaders could be built and still keep the total cost below $600,000. This estimate contains two presumptions which may be unwarranted. First, that the cost of the bait could be reduced to $12.50 per ton, and second, that enough materials would be obtainable for the work.

Between the two approaches to the control of range grasshoppers, the writer favors a combination of prevention together with the poisoning of rather large areas of our best range, even in bad outbreak years. It may appear to many readers that the above paragraphs contain impractical ideas and some unsupported assumptions. That is readily admitted. On the other hand the figures presented are as conservative as possible. Considering the immense importance of this problem at the present time, the state, together with whatever aid may be obtained from the federal government, should make a strenuous effort toward the control of range grasshoppers. It is by way of encouraging the most practical and intelligent solution of the problem that this duscussion has been presented.

LOSSES FROM GRASSHOPPERS AND SAVINGS WHICH HAVE BEEN EFFECTED

Table 4 presents estimates for the past three years on the losses due to grasshopper depredations and the saving resulting from the employment of control measures. Had it not been for

TABLE 4.—LOSSES CAUSED BY GRASSHOPPERS IN MONTANA AND SAVING EFFECTED BY CONTROL MEASURES

Year	Losses			Saving	
	Cultivated crops	Range	Total	Cultivated crops	Range
1934	$5,513,000	$500,000	$6,013,000	$7,500,000	——
1935	2,434,000	600,000	3,034,000	783,000	——
1936	1,900,000	650,000	2,550,000	2,175,000	——
Total	$9,847,000	$1,750,000	$11,597,000	$10,458,000	

the use of poisoned bait against these insects the total loss would have been over $22,000,000. The saving in 1934 was made mostly in north-central Montana where a good grain crop was grown in spite of the heaviest 'hopper infestation in the history of the state. The savings in 1935 and 1936 were made mostly in the irrigated sections.

THE GRASSHOPPER SITUATION FOR 1937

In order to predict the probable extent of grasshopper infestations in 1937, adult and egg surveys were made during the latter part of August, September, and October, 1936. Approximately 250 examinations for adults were made in 43 counties and 247 examinations in 37 counties for grasshopper eggs. From the data collected, a summary of which appears in table 7, heavy infestations are to be expected in Park, Yellowstone, Big Horn, Petroleum, Lewis and Clark, Pondera, and Glacier counties. Moderate infestations can be looked for in all other counties east of the continental divide except Broadwater, Liberty, and McCone which are scheduled for fairly light outbreaks. Beaverhead and Meagher together with the counties west of the divide were not surveyed.

The survey on which the 1937 prediction is based was sup-

TABLE 5.—COMPARISON OF THE AMOUNT OF GRASSHOPPER BAIT ESTIMATED FOR 1937 WITH THE PREDICTED AND ACTUAL AMOUNTS FOR THE THREE PREVIOUS YEARS

Year	No. counties surveyed	Poisoned Bait (Dry Basis)		Acres to Poison	
		Estimated from survey previous fall	Actually used	Estimated from survey previous fall	Actually treated
		Tons	Tons	Acres	Acres
1934	50	18,017	16,254	3,600,000	3,320,000
1935	52	3,073	1,595	600,000	315,000
1936	43	6,271	3,063	1,250,000	612,000
1937	43	7,759	——	1,550,000	——

ported by the United States Bureau of Entomology and Plant Quarantine, the Montana Agricultural Extension Service, and this office. Two men were employed for two and one-half months.

A comparison of the bait needed for 1937 in relation to that predicted and used in the three previous years can be obtained from table 5. In general the outlook for grasshoppers in 1937 is the most serious for any year since 1934. As mentioned in regard to the 1935 grasshopper work, the predictions are sometimes incorrect but, in spite of the errors which creep in, the survey method furnishes the most reliable information available. Attempting to cover such a vast area in a very limited time and with a reasonable expenditure of funds will necessarily result in some mistakes. The goodness of the predictions in 1935 and 1936 can be obtained from table 6 in which the amounts of bait predicted from the survey and the amounts actually used are given. Often such comparisons may be obscured by such factors as drought, delay in control operations, and lack of bait which will, of course, result in less bait being used. This is no reflection on the survey prediction. However, when far more bait was used than was predicted an out and out error in the survey is indicated. Twelve such mistakes were made in 1935 and five in 1936.

THE MORMON CRICKET SITUATION, 1936-1937

Mormon crickets have been on the increase in Montana since 1931. In that year but a few hundred acres in southern Montana were infested. Today the overwintering eggs are in the soil to such an extent that over one million acres will be badly infested next spring and not long after hatching occurs the march of the cricket armies will begin. Sixteen counties are vitally concerned with this problem and two or three others to a less serious extent. In addition, 350,000 acres on the Tongue River and Crow Indian Reservation will be infested in 1937 unless a vigorous campaign of suppression is started early in the season.

Cricket control work for several years has been handicapped by not starting the work at a time when the best results could be obtained. In general, crickets hatch much earlier in the spring than grasshoppers. It is not unusual to have the young crickets

TABLE 6.—AMOUNTS OF GRASSHOPPER BAIT PREDICTED FROM SURVEY DATA AND AMOUNTS ACTUALLY USED IN 1935 AND 1936

County	1935		1936	
	Predicted	Used	Predicted	Used
	Tons	Tons	Tons	Tons
Beaverhead	8.2	26.0	58.6	25.5
Big Horn	0	95.0	282.0	188.0
Blaine	108.0	25.0	180.3	15.0
Carbon	47.0	42.0	263.3	240.0
Carter—Fallon	0	4.0	226.6	.8
Cascade	550.0	80.0	110.2	100.0
Chouteau	398.0	80.0	63.5	20.0
Custer—Powder River	14.0	47.0	292.9	24.0
Daniels	104.8	2.5	104.9	2.0
Dawson	0	5.0	159.6	4.0
Fergus	87.4	70.0	431.7	80.0
Flathead	12.0	0	—	—
Gallatin	71.7	8.7	79.7	84.0
Garfield-Petroleum	19.0	0	437.0	25.0
Glacier	24.6	1.0	34.1	20.0
Hill	228.0	19.0	224.0	26.0
Judith Basin	0	51.0	246.0	35.0
Lake	18.0	.5	—	1.4
Lewis and Clark—Broadwater	45.2	11.5	6.3	24.9
Liberty	135.0	—	33.8	—
McCone	93.0	20.0	124.4	—
Madison—Jefferson	30.5	1.0	—	57.0
Meagher	14.0	—	22.0	—
Missoula	—	—	—	.1
Musselshell—Golden Valley	13.5	90.0	130.5	25.3
Park	120.0	20.0	221.1	46.5
Phillips	0	25.0	51.2	25.5
Pondera	144.3	20.5	165.2	167.5
Powell	0	—	—	—
Prairie	0	47.0	61.9	7.0
Ravalli	0	—	—	—
Richland	0	10.0	210.1	30.0
Roosevelt	0	35.0	166.0	77.0
Rosebud	0	105.0	115.7	120.0
Sanders	6.4	—	—	3.5
Sheridan	91.0	41.0	375.1	65.0
Stillwater	40.0	130.5	389.4	60.0
Sweet Grass	80.3	87.5	121.8	380.0
Teton	269.0	45.0	150.6	190.0
Toole	49.0	26.0	21.6	100.0
Treasure	0	6.0	54.9	—
Valley	152.1	20.0	190.1	14.5
Wheatland	24.0	20.0	77.9	15.0
Wibaux	0	3.0	128.2	10.0
Yellowstone	75.0	170.2	257.2	750.0
Totals	3073.7	1594.9	6271.1	3063.65

appear in late March or early April. As the eggs are more or less concentrated in particular areas and as the young crickets up to the time they are half grown are more gregarious and thereby more susceptible to the dusting method of poisoning than later in the season, early efforts against them are paramount to success.

TABLE 7.—MONTANA GRASSHOPPER SURVEY (1936)
(Prediction for 1937)

County	Infestation			Total crops	To be treated	Bait necessary	Cost
	Egg	Adult	Average				
	Pct.	Pct.	Pct.	Acres	Acres	Tons	
Big Horn	33.9	24.4	33.9	139,019	47,127	235.64	$5891.00
Blaine	3.3	57.7	21.4	188,609	40,362	201.81	5045.25
Broadwater	3.3	14	6.9	38,073	2,627	13.14	328.50
Carbon	20	21	20.3	113,523	23,045	115.23	2280.75
Carter	—	13.1	13.1	79,810	10,455	52.28	1307.00
Cascade	15	30	20.0	208,922	41,784	208.92	5223.00
Chouteau	13.5	34	20.3	346,041	70,246	351.23	8780.75
Custer	28	32	29.3	85,838	25,151	125.76	3144.00
Daniels	5	56	22.0	222,422	48,933	244.67	6116.75
Dawson	25.5	15.9	25.5	219,041	55,855	279.28	6982.00
Fallon	—	25.6	25.6	149.652	38,310	191.55	4788.75
Fergus	16.1	53.5	28.6	359,999	102,960	514.80	12870.00
Gallatin	26.0	13.7	26.0	143,606	37,338	186.69	4667.25
Garfield	0	23.3	12.7	118,929	15,104	75.52	1888.00
Glacier	2.5	70	36.3	71,496	25,953	129.77	3244.25
Golden Valley	—	16.6	16.6	37,036	6,150	30.75	768.75
Hill	10	38	19.3	316,688	61,121	305.61	7640.25
Jefferson	25	18	25.0	34,451	7,407	37.04	926.00
Judith Basin	10	48.5	22.8	175,975	40,122	200.61	5015.25
Lewis and Clark	32.5	33.3	32.8	84,158	27,604	138.02	3450.50
Liberty	3	21	9.0	94,759	8,528	43.64	1066.00
Madison	26.6	27.5	26.9	103,852	27,936	139.68	3492.00
McCone	1.25	17	6.5	186,678	12,134	60.67	1516.75
Musselshell	—	13.5	13.5	52,698	7,114	35.57	889.25
Park	46	38.4	46.0	79,412	36,530	182.65	4566.25
Petroleum	5	61	33.0	40,376	13,324	66.62	1665.50
Phillips	7.6	37	17.4	187,776	32,673	163.37	4084.25
Pondera	31.4	69	43.9	175,830	77,189	385.95	9648.75
Powder River	—	27	27.0	126,654	34,196	170.98	4274.50
Prairie	39.4	29.4	39.4	105,607	41,609	208.05	5201.25
Richland	6.3	52	21.5	255,917	55,022	275.01	6877.75
Roosevelt	3.9	46.6	18.1	322,202	58,319	291.60	7290.00
Rosebud	24.3	12.0	24.3	96,602	23,474	117.37	2934.25
Sheridan	20.8	44	28.5	332,582	94,786	473.93	11848.25
Stillwater	19.1	29.5	22.6	122,982	27,794	138.97	3474.25
Sweetgrass	30	31	30.3	62,009	18,789	93.95	2348.75
Teton	23.3	29	25.2	209,343	52,754	263.77	6594.25
Toole	0	44	14.7	114,747	16,868	84.34	2108.50
Treasure	35	20	35.0	36,462	12,762	63.81	1595.25
Valley	18.9	38	25.3	282,563	71,488	357.44	8936.00
Wheatland	—	17.1	17.1	46,668	7,980	39.90	997.50
Wibaux	17.9	22.1	19.3	102,858	19,858	99.29	2482.25
Yellowstone	43.6	23	43.6	167,276	72,932	364.66	9116.50
						7758.64	$193,966.00

Total acreage involved	1,551,763
Tons of bait needed	7,758.64
Cost	$193,966.00

Control work in early spring can be concentrated on about 10 per cent of the area which will otherwise be infested before the summer is over.

Seventeen WPA projects on cricket control were prepared in

this office in January, 1936, and forwarded to county commissioners for submission to the Works Progress Administration. Several of these were not submitted by the counties at all. Two were approved in May, and on June 5 five other counties were informed that cricket projects could be operated. Of the counties which attempted cricket control under WPA projects, Chouteau perhaps did the most work. The effort there got under way on June 22. Three seven-man crews dusted some 10,000 acres. This dusting was all done after the crickets had reached the adult stage and while it reduced crop damage to some extent action was too long delayed and too limited in extent to cut down the cricket population for another year. The same was true of other counties which operated WPA projects.

The damage from crickets in 1936 was in excess of $340,000 to cultivated crops and an unestablished amount to range areas. In table 8 are presented estimates for cricket control in 1937.

TABLE 8.—ESTIMATED COST OF CRICKET CONTROL FOR 1937

County	Acres infested	Pct. to poison	Acres to poison	Total cost
Big Horn	20,000	10	2,000	$ 3,000.00
Carbon	90,000	"	9,000	13,500.00
Cascade	4,000	"	400	600.00
Chouteau	120,000	"	12,000	18,000.00
Glacier	5,000	"	500	750.00
Judith Basin	60,000	"	6,000	9,000.00
Lake	5,000	"	500	750.00
Pondera	10,000	"	1,000	1,500.00
Park	15,000	"	1,500	2,250.00
Powder River	20,000	"	2,000	3,000.00
Rosebud	220,000	"	22,000	33,000.00
Sweet Grass	30,000	"	3,000	4,500.00
Stillwater	15,000	"	1,500	2,250.00
Treasure	20,000	"	2,000	3,000.00
Yellowstone	25,000	"	2,500	3,750.00
Wheatland	20,000	"	2,000	3,000.00
Tongue River I. R.	50,000	"	5,000	7,500.00
Crow I. R.	300,000	"	30,000	45,000.00
Total	1,029,000		102,900	154,350.00

FINANCIAL SUPPORT FOR GRASSHOPPER AND CRICKET CONTROL IN MONTANA IN 1937

To protect cultivated crops in Montana from grasshoppers and crickets during 1937 and furnish very limited protection to range areas close to such cultivated crops, the costs will be about as follows:

For Grasshoppers		
6,559 tons of poisoned bait ($25.00)	$165,000.00	
Operation of mixing stations, local transportation, etc.	12,470.00	
Labor, distribution of bait	none	
		$177,470.00
For Crickets		
Poisoned dust	38,587.00	
Expense connected with operation of mixing stations, establishment of camps, camp equipment, local transportation	24,940.00	
Labor for dusting	154,350.00	
		217,877.00
Total for both grasshoppers and crickets		$395,347.00

There are 21 other states in the west and middle west with critical grasshopper situations. There are 7 states in the intermountain region facing cricket outbreaks. On October 23, 1936, representatives of the states interested in cricket control met at Pocatello, Idaho, to lay plans for the coming year. None of these representatives was in favor of attempting another cricket campaign as a Works Progress Administration project. Reasons for this are many, but in brief cricket-control work is not a suitable project for WPA. Crickets must be dusted early in the morning and in the evening. The hours of labor are thus very irregular as are the times of day when the work must be done. It is very desirable therefore, if not almost essential, for the men to live in camps close to the field of operations. Sentiment at this meeting was strongly in favor of a cooperative arrangement between the federal government (Bureau of Entomology and Plant Quarantine, United States Department of Agriculture) and infested counties. It was proposed that the federal government furnish the labor necessary for applying the dust and the counties provide the materials and take care of the expense incident to the establishment of camps. The maintenance of the camps would be paid from the daily wage of the men occupying them. Under such an arrangement farmers as well as men from relief rolls could be engaged in the work thereby providing enough local men to create a strong sense of responsibility in handling the poisonous materials. Furthermore by paying a reasonable wage the work could be done at

the most opportune time. The division of costs would be three-fifths federal government and two-fifths county.

Following the cricket meeting in Pocatello, the entomologists of 22 western and middle western states, together with many of the commissioners of agriculture of those states, met at Omaha, Nebraska, on December 4-5, 1936, to consider the 1937 grasshopper work. The proposal was made that the Congress of the United States create a fund of $5,000,000 to be administered by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture and used to finance control operations against *insects of regional importance,* such as grasshoppers, chinch bugs, etc. Each succeeding congress would be asked to replenish this fund to its original amount. During some years none of this fund would be used. Decision relative to the species of insects against which the fund could be employed would rest with a technical committee appointed by the Secretary of Agriculture. The plan has rather wide support and is very likely to be adopted. Its chief merit is that it would make possible timely and concerted action against insects which affect whole agricultural regions. It would place the work on a sound basis instead of putting the control of such insects on an emergency basis, often with appropriations of money made too late in the year to give effective control.

If this plan receives favorable action by congress, money would be available for the control of both grasshoppers and crickets. However, to be of much value for cricket control in 1937, the measure would have to pass congress by March 15 to April 1 at the latest. With some doubt as to this possibility, the intermountain states are asking a special appropriation for cricket control should it become evident that the $5,000,000 fund will be delayed. In case a special cricket appropriation is obtained, the suggested cooperative arrangement between the federal government and the counties would likely hold; if the larger fund is released in time for crickets that will not be the case. Certain commitments by counties will undoubtedly be required, however, such as the cost of operating mixing stations and local transportation in the case of both grasshoppers and crickets, and the additional cost for the establishment of camps in the case of crickets.

State Support.—At a meeting of farmers, stockmen, county commissioners and others interested in insect control held at Billings on December 9, 1936, it was voted to ask the State of Montana to share with the counties the cost of the work against grasshoppers and crickets. As indicated in the paragraphs above even with the federal government aiding very greatly by furnishing materials, labor, and transportation of materials to central points, there are certain expenses which must be met by counties. If federal money is available for cricket control in 1937 the county expense will be rather high. It is thus proposed that the state make an appropriation, available July 1, 1937 and a like sum on July 1, 1938 to reimburse the counties on a two-thirds state one-third county division. Should the sum be inadequate to meet this requirement, then the state money would be pro-rated to the counties in accordance with their insect-campaign expenses.

If the $5,000,000 fund is passed by congress in time to take care of cricket control as well as grasshoppers, the expense to be met by all the counties will be approximately $37,410. If the fund goes through early enough to take care of grasshoppers only and a special federal appropriation for crickets is made on a county-cooperation basis, the total expense for all the counties will be greater, namely about $75,997.

IMPORTANT INSECTS OF THE YEARS 1935-1936

THE PALE WESTERN CUTWORM

The abundance of pale western cutworms *(Agrotis orthogonia* Morr.*)* is closely related to rainfall. When the May and June rainfall is low, conditions are favorable to cutworm increase. With two consecutive seasons of low rainfall (less than 3 inches) in May and June, a great increase in this cutworm may be expected. Twelve counties (Teton, Pondera, Glacier, Toole, Liberty, Hill, Chouteau, Blaine, Phillips, Valley, Fergus, and Cascade) are facing such a situation in 1937. More damage to grain crops was done in some of these counties in 1936 by pale western cutworm than for many years, with the possible exception of 1932. As soon as rainfall data were avilable last summer a warning was sent out relative to the danger of cultivating summer fallow in the above areas during the period of August 15 to September 15. Cultivation or seeding operations at that time breaks the slight crust which has been formed by any light rains and makes the soil very attractive to the female moths for depositing their eggs.

So far as winter wheat is concerned, the die is cast. The eggs have been laid and next spring they will hatch into young cutworms. More or less the same condition is true of land on which spring wheat or other grain is to be seeded. If cutworms are going to be present next season on that land, the eggs are already present. There is this difference, however. In Alberta it has been found that the very young larvae cannot withstand starvation. After the eggs hatch the young worms must have some green food or they die. This offers some hope and suggests the possibility that if the land is not seeded for a few days following its thorough preparation for seeding, many of the insects may be starved out. The effectiveness of such an attempt at control would depend on knowing when the eggs hatch. An effort will be made this coming spring to give farmers in the threatened region this information.

SAY'S PLANT BUG

Say's Plant Bug was not so noticeable in 1936 on account of the reduction of wheat by drought and grasshoppers. Nevertheless they were numerous over the north-central area in

which damage has been reported for the past four years. A new occurrence was found in irrigated wheat at Malta. A field laboratory was established at Big Sandy and observations made during the summer months. Weedy fields provide the principal hibernation quarters. The first eggs appeared in May and until October there were only about two weeks when egg laying was not observed. The peak of the second generation egg laying was in July. The average number of eggs in each of several hundred egg masses was 30, and hatching occurred in from 4 to 7 days, depending on the temperature. Humidity apparently had little effect on hatching. The chalcid egg parasite, *Telelonomous ashmeadi,* was numerous. While some egg masses were parasitized 100 per cent, the total parasitism of eggs collected in the field was only 10 per cent. A small Melyrid beetle, *Cololps bipunctatus,* was numerous and an active predator on the eggs but its actual control value is doubtful. Three species of adult parasites were reared from field collected bugs. These are the tachinid flies, *Gymnosoma fuliginosa, Cylindromyia armata,* and *Senotainia vigilans.* The latter two have not hitherto been reported as parasites of Say's plant bug. Many of the adult parasites overwinter as pupae in the hibernating host. Adult parasitism of field collected bugs was 11.7 per cent.

Spring burning of weeds and trash in infested fields, idle lands, and weedy roadsides appears to be the only method of controlling Say's Plant Bug.

THE BEET WEBWORM

Beet webworms (see figure 3) appeared in great numbers in 1936 for the first time since the unprecedented outbreak of 1932. There are usually two full generations of this insect in Montana. The moths which develop from overwintering larvae appear in May and early June, their eggs producing the first generation of worms in late June and the first part of July. Moths from the first generation of webworms occur late in July and lay eggs for a second generation of worms in August. It is the first generation of webworms which causes by far the greatest amount of damage to field beets, gardens, alfalfa, peas, etc.

First Generation, 1936

The moth flight was light in most of the Yellowstone Valley, and in Jefferson, Gallatin, Glacier, Toole, Flathead, Lake, Ravalli, and Beaverhead counties.

Moderate flights appeared in Rosebud, Custer, Prairie, Dawson, Richland, Broadwater, Lewis and Clark, and Teton counties.

Heavy flights of moths were present in Sweet Grass, Fergus, Judith Basin, Cascade, Blaine, Phillips, and Valley counties.

Webworms appeared throughout all the above-named counties but the heaviest, though spotted, outbreaks occurred in Blaine, Custer, Sweet Grass, Gallatin, Jefferson, Silver Bow, Beaverhead, and Lake counties.

Extensive spraying for webworms was carried out in Blaine, Richland, and Yellowstone counties. Intensive work had to be done in the vicinity of Butte to prevent migrations into the city where dwelling houses were being invaded with the worms. Practically all the green vegetation with the exception of cotton-

Figure 3.—The sugar-beet webworm, *(Loxostege sticticalis* L.) greatly enlarged.

wood trees was attacked. This migration could have been completely checked if the worms had been discovered before they left the weedy patches out on the flat where they developed and from which the migrations started.

The greatest losses to sugar beets occurred in the vicinity of Chinook and Harlem. In these areas the worms got into the fields when the beets were only 2 or 3 inches high and not large enough to get the proper effects from spraying. Some fields were completely destroyed when they were invaded early. Part of this unseasonal attack was the result of drought which prevented the growth in waste places of the early food plants (Russian thistle and pigweed), thus causing the very young worms to migrate to the young beets. Usually the migration does not occur until the beets are much larger. Heavy damage to beets was suffered also on the lower Yellowstone.

In sections of Pondera and Phillips counties about 90 per cent of the female moths were sterile so practically no eggs were laid.

Second Generation, 1936

A heavy flight of moths was observed over practically the entire state but, with the exception of the Triangle Area, a high percentage of them was sterile, resulting in a very light second generation of worms. Fergus, Judith Basin, and Blaine counties had second generation webworms in small numbers.

The beet webworm since 1934 has been made the subject of an exhaustive study by the Montana Agricultural Experiment Station. Particular attention is being paid to improved methods of control, to the possibilities of accurately forecasting outbreaks, and to certain physiological and ecological factors which are important from the control standpoint.

BLISTER BEETLES

A scourge to field beets, potatoes, gardens, and ornamentals during 1935 and 1936, were various species of blister beetles with the spotted blister beetle *(Epicauta maculata* Say*)* predominant. Thousands of acres of beets were lost because of these insects and more damage would have resulted had not arsenical sprays and dusts been employed. A rise in the number of blister beetles always accompanies years of grasshopper abundance because, in the larval stage, the blister beetles feed on grasshopper eggs.

THE FALSE CHINCH BUG

In point of numbers this small insect, a close relative to the true chinch bug, was the greatest pest in irrigated sections of Montana in 1936. In the lower Yellowstone country potatoes were severely injured and often stunted to the point of crop failure by heavy swarms of these tiny insects. The wingless nymphs swarmed into cultivated fields from surrounding grass ands where they went through the first part of their development. The drought forced greater numbers to migrate to irrigated crops and must as well have been very favorable to the production of the species. Potatoes and gardens suffered the most. Corn seemed to recover from what at first appeared to be rather serious injury.

FRUIT INSECTS

The Flathead Valley cherry orchards have several insect pest problems. Chief among these is the black cherry aphid *(Myzus cerasi* Fab.*)* which sucks sap from the leaves of the succulunt terminal growth, causing the terminals to become misshapen. On young trees this is particularly undesirable and all of the Flathead cherry orchards consist of young trees. Practically 100 per cent of the Flathead sweet cherry trees were killed in the unseasonal freeze of October, 1935, but the majority of the growers will have their orchards replanted by 1937 or 1938. The cherry aphid problem will then become acute unless control measures are carried out.

Field tests during the 1935 season showed that the cherry aphid could be controlled nearly 100 per cent with a single spray application. The best spray formula proved to be a summer spray oil 2½ gallons, water to make 100 gallons, and nicotine sulphate (Black Leaf 40) ¾ pint. This was applied after the buds had swollen and showed green on the tips and just as they began to open. (See figure 4).

Cherry growers are still somewhat skeptical of controlling the black cherry aphid by spraying. This is occasioned by improper spraying in the past. There is little or no chance of controlling the aphids after the leaves have curled. The aphids migrate from the cherry trees late in summer after their damage is done and this fact often gives the grower the idea that a late season spray killed them, as numerous cast skins are left behind. The spray must be applied early in the spring after the eggs have hatched and before the aphids can seek cover on the trees, for the spray must come in direct contact with their bodies. The entire tree must be drenched with the spray regardless of the amount which falls to the ground as waste. High pressure machines are essential to force the spray into crevices of the tree where aphids may be seeking shelter. Probably the only way to convince the cherry grower of the efficiency of this procedure is to conduct spraying demonstrations in representative orchards in each district.

The cherry fruit fly *(Rhagoletis fausta* O. S.*)* is apt to be relegated to minor importance until the cherry orchards come into bearing again. It is much more than a "scare" as indicated in the last State Entomologist Report. Sour cherry orchards

unsprayed for two seasons yielded 40 per cent wormy cherries in the 1935 season. Maggots were found in sweet cherries in several locations near sour cherry trees. In one sour cherry orchard where control measures have been in force for four seasons the infestation remains at a fraction of 1 per cent and

Figure 4.—Sweet cherry buds in different stages of development. The correct time for applying the spray for the black cherry aphid is shown in the twig to the right.

no worms occur in sweet varieties. It is not desirable to eradicate sour cherry trees, the preferred hosts, but rather use them as a trap crop and thus keep the fly population down. The flies also propagate in wild pin cherries, the original host.

Observations over the past four seasons indicate that in odd years a much larger number of fruit flies emerge than

during even years. In 1933 many maggots were reported, in 1934 very few flies or maggots were found, in 1935 quite a number of flies were taken and many maggots found, then again in 1936 fly and maggot populations were very low. It is safe to predict that in 1937 cherry fruit flies will be numerous around sour and wild cherries, but not in sweet varieties as the new trees will not be bearing.

A golden opportunity is afforded during the next three seasons to practically eliminate the cherry fruit fly as a pest of the Flathead cherry industry before the sweet cherry trees come into bearing. This can be accomplished, first, by eradicating all wild pin cherry trees near orchards, or spraying them, and second, by spraying all sour cherry trees. Tests during 1934, 1935, and 1936 have shown the efficiency of lead arsenate spray in reducing infestations. Lead arsenate ½ pound in 10 gallons of water sprayed in coarse drops with low pressure about one quart per tree is the recommended practice. This is usually applied twice, a week apart, the first when the fruit is just showing color. The exact time depends on the appearance of the flies.

The codling moth *(Carpocapsa pomonella* L.) is very troublesome to Montana apple growers. Only one brood appears in a single season but is spread over most of the season. This factor combined with rather indifferent spraying practices has brought about severe apple losses in a number of places. A carefully applied calyx spray followed by two cover sprays, properly timed by the weather and emergence of moths, gives satisfactory control. Lead arsenate 3 pounds to 100 gallons of water plus 1 pound of spreader remains the standard formula. This pest has not as yet reached all Montana apple trees. This past season it was reported for the first time in Ronan. It is especially bad in towns where back yard trees are not properly sprayed.

The Oyster-shell scale *(Lepidosaphes ulmi* L.) warrants consideration as it is so prevalent on apple trees. Tests during 1935 and 1936 of various spray materials showed that liquid lime sulphur 28-32° Baume at 1 gallon to 8 gallons of water applied as a dormant spray, gave the best control. Where apple scap sprays of liquid lime sulphur 1 to 25 have been used regularly, oyster-shell scale has not become a pest. Dry lime sulphur and

dormant summer spray oils should be used only in the event liquid lime sulphur cannot be obtained, as they appear to be less efficient under Montana conditions.

Yellow Jackets *(Vespidae)* appear in cycles. In 1933 apparently there were none. In 1934 there were quite a number but they appeared too late to damage the fruit crop appreciably. The season of 1935 saw considerable damage to the cherry and berry crops by yellow jackets. Early in 1936 "queen" yellow jackets were numerous. As the season advanced these ceased to appear, which is normal, but "worker" yellow jackets failed to appear in their place as is usual, only an occasional one being seen all season.

Undoubtedly there is some natural force which checks the yellow jackets after they have increased over a three-year period. In 1935 a few tests with fly traps and poisoned baits established the fact that they preferred ground meat, such as liver, to fermented fruit or fresh fruit, such as cherries. This factor might be used in drawing them away from feeding on ripe berries or cherries. Sodium arsenite failed to function as a poison as it repelled the wasps from the bait. Baghouse arsenic baits gave a high per cent of kill. Considering all angles the poisoned bait or fly trap is much too slow a procedure for wasp control once they start attacking the fruit.

Other Orchard Insects

New orchards, especially those planted on newly cleared land, are often seriously defoliated by a number of species of leaf-feeding insects. Probably the most important of these are the pear and cherry slug *(Eriocampoides limacina* Retz.*)*, and other undetermined slug feeding on cherry leaves, both of which made their appearance for the first time in the Flathead Valley this year. The former attacks the upper surface of the leaf, is very dark green, enlarged at the head end and holds the tail end up from the surface of the leaf. The latter (figure 5) attacks the lower surface of the leaf, is very pale green, tapers from head to tail, and does not hold the tail end erect. Tests during 1935 gave nearly 100 per cent control with contact sprays and dusts, stomach poison sprays and dusts, and hydrated lime as a dust. Even ordinary road dust gave 75 per cent control. With this evidence a slug infestation appears to be caused chiefly by neglect or lack of knowledge on the part of the orcharist.

A number of species of caterpillars have been found on the leaves of the young trees. No one species is numerous enough to demand attention but the combined feeding of these forms is a serious drain on the vitality of the growing trees. A covering of lead arsenate spray 2 pounds to 100 gallons of water plus 1 pound of spreader applied after the trees came into full leaf would check most of this damage. The feeding is confined largely to the mature leaves rather than the growing tips. This

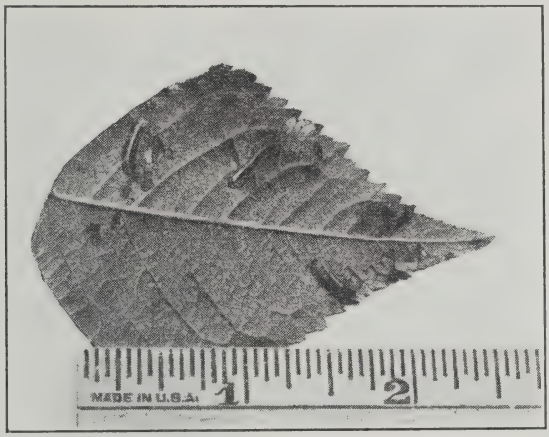


Figure 5.—Larvae of the cherry saw-fly.

spray would also take care of the slugs although a second application would probably be needed in late July or August for the second brood of slugs.

Old orchards suffer somewhat from the same insects but where sprays for codling moth are applied they ceased to be of importance on apple trees. Cherry fruit-fly sprays are an aid to old cherry trees in this respect.

SMALL FRUIT INSECTS

The Strawberry Root Weevil *(Brachyrhinus ovatus* L.*)* is the major insect pest of western Montana strawberries. In the grub stage it attacks the roots and crowns of the plants. The adult beetles feed on the leaves and fruit. A cultural program allowing the berry plants to grow only two seasons, plowing them under in the fall of the second season, and growing a cover

crop the following season is a distinct aid in control. The best method of checking this insect is by the use of a poisoned bait. This is placed in the crown of the plants at the rate of about 50 pounds to the acre. Tests of a number of bait formulae recommended by other workers showed poisoned, ground dried-apple bait to be superior in attracting the weevils and in killing them. A formula devised in Montana employing half bran in the bait made it much cheaper and just as effective. The bait consists of 10 per cent by weight of baghouse arsenic, 45 per cent of bran, and 45 per cent of dried apple. Grinding the dried apple by power or in a meat chopper is much easier if the bran is ground with it. Water is added to make a crumbly mass of the bait. It should be applied in the spring when the overwintering weevils appear, usually in April, and again later in the summer when the newly emerged weevils appear, about the last of June or early in July. Strawberry growers generally do not realize what is killing their plants and of course do not know how to control this pest. Nearly every strawberry grower in western Montana is confronted with this pest and needs to be advised of means of control. At present the dried apple bait for strawberry root weevils is covered by a patent so growers are subject to an infringement suit if they use it. However, growers in other Pacific northwest states make their own dried apple bait and no suit has ever been brought against a grower.

The strawberry leaf roller *(Ancylis comptana* Frohl.*)* is common in western Montana but usually does not develop in damaging numbers. Last season, however, in a few places through lack of information, it had developed to a serious pest. It was readily demonstrated that a lead arsenate spray 1 pound to 50 gallons of water applied before the leaves had rolled was effective in reducing the numbers. Contact sprays of oil and nicotine and nicotine and soap also gave satisfactory results. This latter might be used when there is danger of poisoning the fruit. Two applications of spray are needed, applied before the development of each crop of berries. Again high pressure spraying is essential to thoroughly coat the foliage.

The raspberry sawfly *(Monophadnoides rubi* Harris*)* appeared in harmful numbers in several locations in western Montana last year. The immature form of the sawfly looks like a many-legged, fuzzy, green caterpillar. In feeding it eats out

all of the leaf tissues leaving just the leaf ribs. The application of a lead arsenate spray 1 pound to 50 gallons of water in late April or early May, depending on the season, would give effective control. Annual spraying is not essential. It is safe to advise spraying only following seasons of severe infestation, or when the lower leaves of the plant exhibit many fine holes from feeding by the young worms early in the season.

THE FOREST TENT CATERPILLAR

The most conspicuous insect on shade trees in 1936 was the forest tent caterpillar *(Malacosoma disstria* Hbn.*)* Along the upper Yellowstone and particularly in Livingston's Island Park, cottonwood trees were completely defoliated by these insects. Of the hundreds of trees in that park only one was noticed which had been overlooked by the caterpillars. The trees sent out new growth during the latter part of the summer and probably suffered no permanent injury but the appearance and usefulness of the park up to July was ruined. In the case of such tall trees control is difficult if not impossible without proper equipment for dusting or spraying the foliage rather early in the season while the caterpillars are still small. At that time they are easily killed by arsenicals.

This species does not build a tent like its close relative the apple tree tent caterpillar and for that reason has been named the "tentless" tent caterpillar. The larvae instead of hiding away in a tent congregate in great masses in the crotches of the branches. They are about two inches long when full grown and are a dusky brown in color with fine yellowish-brown stripes on the back and sides. They are covered with long fine brown hairs. There is but a single brood. Pupation occurs in a silken cocoon attached to any convenient place on the trees or nearby objects. The adult moths vary in color from reddish to fawn, the males being smaller and much darker than the females. They emerge from the cocoons in midsummer and the females deposit their eggs in rings around the smaller twigs. The eggs develop into young caterpillars by fall but the young worms do not leave the egg shell until the following spring when the leaves begin to unfurl.

VIRGINIA CREEPER LEAFHOPPER

Erythroneura comes zic-zac Walsh

The attention of the State Entomologist's office was first drawn to this insect in August of 1907, when specimens and injured foliage were received from Billings. It was not until 1926 that injury was again reported, this time from Glasgow. Garfield, Rosebud, Custer, and Powder River counties reported

Figure 6.—That part of the vine to the right was protected from the Virginia creeper leafhopper by a single spray; the vines to the left were unsprayed.

it in 1928, Park and Lewis and Clark counties in 1929, Prairie County in 1930, and Dawson County in 1931. It has up to the present time been reported from or observed in all parts of the state except the extreme west and the northwestern corner.

The Virginia Creeper leafhopper is a minute, elongate, pale yellow insect with a conspicuous rusty-brown zig-zagging stripe on each wing. It sucks the juices from the leaves, giving them a gray, mottled appearance. When the pests are abundant the leaves are so injured that they drop from the vines.

The biology and control of this insect have been studied at Bozeman, and control experiments were quite successfull. The

leafhopper hibernates as an adult, flying in the spring to the vines where it lays its eggs within the leaf tissue. When these eggs hatch the nymphs join the adults in their depredations. At Bozeman there is apparently one complete generation and a partial second.

The best control was obtained by spraying the vines shortly after the first nymphs became noticeable on the under sides of the leaves. Treatment before this time did not give satisfactory results, and spraying after this period was too late to prevent considerable injury. If the leaf hoppers are abundant, though, spraying is advisable at any time during the summer.

While community action against these insects is no doubt desirable, that it is not essential can be seen from figure 6. This shows how a part of a large Virginia creeper was protected by one application of spray. The picture was taken in September and the part of the vine to the left has been completely defoliated. The sprayed portion is still green.

The greatest degree of control was obtained with the following mixture:

1 2/3 ounces nicotine (Black Leaf 40)
8 ounces summer oil emulsion
5 gallons water

The oil should be placed in a suitable container and the water added slowly and with continuous agitation until a uniform milky emulsion is obtained. The nicotine is thoroughly mixed with the emulsion just before the spray mixture is to be applied. Its effect is rapidly lost if the mixture is allowed to stand for any length of time.

If a summer oil is not available it may be made as follows:

To one part of skimmed milk add *very slowly* two parts of a good grade No. 10 viscosity lubricating oil such as may be purchased at any filling station. The mixture must be thoroughly agitated all the while that the oil is being added. An electric kitchen mixer or a common egg-beater may be used for this purpose. If properly made, the resulting emulsion is heavy and white with no evidence of free oil.

The spray mixture should be liberallly applied to both sides of the vines if possible. The under sides of the leaves should be

thoroughly drenched as the success of the treatment depends largely upon the thorough wetting of all of the foliage.

ALPINE ROCK CRAWLER

Grylloblatta campodeiformis Walker

This rare alpine insect (figure 7) was discovered for the first time in Montana during September, 1936. It has been collected previously at a few points in the northern Rocky Mountains, as far north as Banff, Alberta, and now as far south as southern Gallatin County, Montana, although we are by no means certain that these points represent the extremities of its range.

The physical requirements of this insect are interesting in that its normal range of activity lies between 32°F. and 60°F., with an optimum indicated at about 38°F. It cannot survive 80° F., a temperature at which the most of our summer insects are active.

While this insect is too rare and too limited in its habitat to be of economic importance, it is likely that its primitive nature will allow rather definite deductions to be drawn as to the relationships of many of our present-day destructive insects.

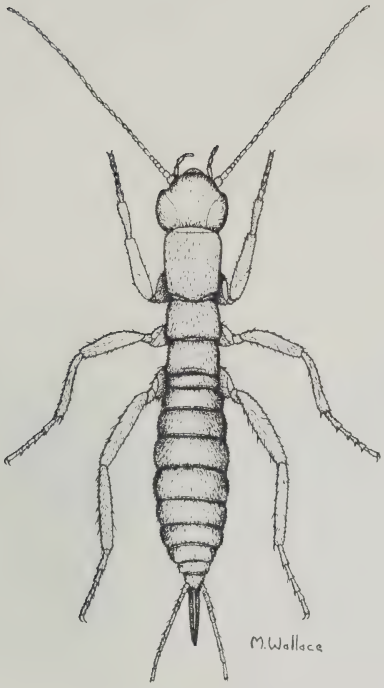


Figure 7.—Gryoblatta, a rare and primitive alpine insect collected for the first time in Montana in 1936.

BOZEMAN CHRONICLE PRINT

95.7
76
27
op.2

TIN NO. 366 JANUARY, 1939

Montana Insect Pests For 1937 and 1938

THE TWENTY-SEVENTH REPORT OF THE STATE ENTOMOLOGIST OF MONTANA

BY

HARLOW B. MILLS, STATE ENTOMOLOGIST

Figure 1.—Adult of the sugar beet webworm (*Loxostege sticticalis* L.)

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA.

2

Natural History Survey
Library

LETTER OF TRANSMITTAL

Bozeman, Montana.
December 15, 1938.

To His Excellency,
Governor Roy E. Ayres,
Helena, Montana.
My Dear Sir:

I present herewith the 27th Report of the State Entomologist of Montana.

There have been some changes in the status of the insect outbreaks reported to you for 1935 and 1936. Grasshopper injury was intense in parts of the State in 1937, the areas affected most severely being affected also by drought. For 1938 a great decrease in infestation was forecast, and this decrease was clearly evident up until July 1, 1938. The injury caused by these pests would have been the smallest on record for Montana in many years had not an invasion from the Dakotas occurred in July. This invasion cost Montana over six millions of dollars but, fortunately, such mass migrations involving large areas seldom occur. Indications are that "native" Montana 'hoppers will be considerably more abundant in 1939 than they were in 1938.

The worst infestation of Mormon crickets ever experienced by this or any other State occurred in 1937 and was successfully combatted through an allocation of W. P. A. funds. Crops valued at over five million dollars were saved and about five hundred thousand dollars worth of crops were lost. In 1938 there was a change in procedure in fighting these pests, involving a reduction in hand labor and an increase in the use of power dusters and barriers. Again the savings-loss ratio was about 10:1. Control work for these pests is working toward a sounder basis.

The Federal side of insect control is now invested in a division of the Bureau of Entomology and Plant Quarantine which is in charge of control procedure alone. Definite contributions are required of the State in order to receive this Federal assistance. The direction of these cooperative projects in the State is the duty of the State Entomologist. Responsibility for the financing of these campaigns falls, however, on several agencies and groups. I should like to call your attention especially to the discussion of this distribution of responsibility, and suggestions for its equalization among those involved, as given in this report.

Respectfully submitted,
Harlow B. Mills,
State Entomologist.

Twenty-Seventh Report of the State Entomologist

Harlow B. Mills

INSECT CONTROL IN MONTANA, 1937-1938

Since 1930 large scale control of insect pests in Montana has received increasing attention. During the drought of the past few years certain insects have increased greatly in numbers and have been of serious concern to Montana farmers. Assistance for the control of grasshoppers and Mormon crickets increased during the last biennium, both from State and Federal sources, and a considerable measure of success was experienced.

Indications are that grasshoppers will be considerably more abundant in 1939 than in 1938, and that Mormon crickets are increasing in some areas of the State and decreasing in others. It is therefore, highly essential that both of these major crop pests be considered seriously in farming operations next year.

The control of insect pests in the State of Montana should not be considered a passing thing. If we can reason from past experience the farmers of the State, in approximately two-thirds of the years to come, will have to fight grasshoppers and Mormon crickets. In going through the past Reports of the State Entomologist we find that outbreaks of grasshoppers or Mormon crickets have occurred in 25 out of the last 37 years in some parts of the State. This does not take into consideration outbreaks of such insects as sugar beet webworms, blister beetles, army cutworms, pale western cutworms, etc. Further, many insects such as the codling moth and cabbage butterfly are with us constantly. *Insect control, then, must enter into any long-time planning for the agriculture of Montana,* along with soil conservation and rebuilding, water conservation, and other factors of major importance to the agriculture of the State.

Where does the responsibility for financing insect control campaigns lie?—The insect pests which have been receiving the most attention from the control standpoint during the past few years are grasshoppers and Mormon crickets. Both of these pests are migratory and may travel many miles during the season, and both will eat almost any vegetation. Control, then,

is not an individual problem. Mormon crickets notoriously migrate on foot in large bands from one farm to another, one county to another, and even from one state to another. Grasshoppers commonly migrate locally every year, and occasionally, as in 1938, they fly in large hordes for great distances.

Responsibility for assistance in control lies with all owners of agricultural or other lands upon which they may breed. These owners include the Federal Government, the State, the counties, corporations, farmers, etc. All of these groups have a responsibility, and all have been meeting it to a greater or lesser extent. The proportion of land ownership might be a logical basis from which to figure proportionate responsibility. Of the 92,737,869 acres in the State, the following are the percentages of ownership:[1]

Groups	*Per-Cent*
Federal	35.64
State	5.67
County	2.72
Miscellaneous	.07
Corporate groups	14.25
Non-resident individuals	10.89
Resident individuals	30.75

Responsibility, then, would fall in the following order: individual, Federal Government, corporate groups, State, and county. The actual distribution of responsibility during the past two years has been: individual (including labor involved), Federal, county, State, and corporations. The State is not giving its proper proportion of assistance in insect control, and land-owning corporations are contributing very little. The problem of obtaining assistance from these corporations and from non-resident land owners deserves considerable attention. Non-resident land owners represent the most difficult group from which to obtain assistance. The logical procedure would be to assess a percentage of the cost of control work carried on on their lands, or of benefit to their lands, as taxes. Corporate owners are fewer in number and their assistance might be more easily obtained. The State's contribution could be cared for easily by

[1]Renne, R. R., Montana Land Ownership, Mont. Agr. Exp. Sta. Bul. 322, 1936.

increased appropriation to the office of the State Entomologist and by some form of repayment to the counties for a part of their expenditures in insect control.

Figure 2.—Migratory 'hoppers on wheat, Garfield County, July, 1938. Courtesy U. S. Bureau of Entomology and Plant Quarantine.

The State Entomologist is the responsible agent for the prosecution of insect control campaigns in the State. His primary work is with the Montana Agricultural Experiment Station and the Montana State College. However, this contact between control work and investigation is highly desirable, because for the methods used control is wholly dependent on investigation, if it is to be in any measure successful. For the field work the State Entomologist must have sufficient assistance to

properly carry out the duties required of the office.

The appropriation provided by the last session of the Montana Legislature made possible the employment of two full-time assistants, Mr. O. B. Hitchcock, who has been working on Mormon cricket control activities, and Mr. H. R. Willis, for the grasshopper campaign. It also made possible the hiring of temporary help, the puchase of a limited amount of equipment and the rental of district warehouses for the storage of materials purchased by the Federal Government. In addition a small amount of investigation into the effect of Mormon crickets on the range, and an extension of the annual grasshopper survey was carried on.

Further research is necessary because, while it is true that a measure of control has been developed for the great majority of harmful insects, there are few if any for which these methods cannot be refined in effectiveness and cost or new ones discovered. One line of research of extreme importance, but not yet receiving its proportionate share of attention, is that of forecasting increases in insect populations. Certain insects seem to do best in dry weather, others in wet. For the majority of them, however, the factors governing their increase or decrease are not known. In 1936 there were serious outbreaks of the false chinch bug (*Nysius ericae* Schil.) and the forest tent caterpillar (*Malacosoma disstria* Hbn.). The next year they were absent in any numbers and the lined sphinx moth (*Celerio lineata* Fab.) was abundant. In 1932 the Say's grain bug (*Chlorochroa sayi* Stal.), which had been observed in small numbers in the State since 1901, appeared in large numbers and caused considerable injury to wheat in the Triangle Area north of Great Falls. It has remained in injurious numbers up to the present time. When its period of high populations will end is not known. This past summer the common field cricket (*Gryllus assimilis* Fabr.) has been extraordinarily abundant in many areas in the northern tier of counties, and in some places farther south. It is not known whether or not it will increase to injurious numbers next season. Until information is available concerning the factors governing these increases in insect populations, the actual control work will be greatly handicapped.

Figure 3.—Wheat field destroyed by lesser migratory locust, Garfield County, July, 1938. Courtesy U. S. Bureau of Entomology and Plant Quarantine.

GRASSHOPPER CONTROL

General Conditions During 1937-1938

The 1937 season was similar to several preceding seasons in that drought conditions prevailed in many parts of the State. The hatching of grasshoppers started approximately the middle of May and was rather local in its occurrence. In the mountainous western third of the State there was a great mixture of species including *Camnula pellucida* (clear winged locust), *Melanoplus mexicanus* (lesser migratory locust), *M. packardi, M. infantilis, Chorthippus,* and others. Throughout the eastern

two-thirds of the State, *M. mexicanus* was the dominant form. In the southern half of this area *Aulocara elliotti* (big-headed locust) occurred in considerable numbers, and *M. packardi* and *M. bivittatus* to a less extent. Conditions in the north half of this area were similar, but *M. packardi* was possibly more abundant in many areas than *A. elliotti.* For the first time, at least in many years, the eastern *M. differentialis* (differential locust) was a dominant species. In some of the irrigated sections of Richland County the species was present in large numbers and laid many eggs.

No critical injuries to humans were reported as a result of the 1937 campaign. Thirty-two domestic animals died as a result of careless exposure of bait or bait materials.

The 1938 season was characterized by a definite break in the drought period, and both cultivated and wild vegetation grew luxuriantly throughout practically all of the State. Hatching of grasshoppers was from 4 to 6 weeks late, not being well under way until after the first week in June. Small numbers continued to hatch throughout the season. Rankness of vegetation doubtless contributed to this late and long-continued hatch. In fact on ranches near Wilsall, in Park County, there was practically no hatch until the first cutting of alfalfa was removed. The hatch became general on these fields as the soil warmed up.

In the western third of the State there was again a great variety of species, the most of the damage to crops being attributed to *Camnula pellucida, Melanoplus mexicanus,* and *M. packardi.* In the central third of the State *M. bivittatus, M. packardi, C. pellucida,* and *A. elliotti,* were dominant. In the eastern third *M. mexicanus* was dominant, with local concentrations of *M. bivittatus, M. femur-rubrum,* and *M. differentialis* in injurious numbers up the Yellowstone Valley into Custer County.

The increase of cool damp weather over the State was doubtless an important factor in reducing grasshopper populations in 1938. Locally, fungus was efficient in keeping numbers down, and, although Sarcophagid flies were not observed to be present in excessive numbers, there was a constant reduction in grasshopper numbers due to parasitism caused by maggots. It is

TABLE 1.—LOSSES FROM GRASSHOPPERS AND SAVINGS FROM CONTROL WORK IN DOLLARS

County	1937		1938	
	Loss	Savings	Loss	Savings
Beaverhead	9,000	20,000	700	—
Big Horn	2,000	8,250	700	1,000
Blaine	99,000	125,000	2,000	1,500
Lewis and Clark and	34,400	27,000	—	—
Broadwater	20,910	30,455	2,405	5,900
Carbon	2,300	14,300	5,300	6,500
Carter and Fallon	175,000	42,900	129,450	64,000
Cascade	1,150	7,100	—	—
Chouteau	10,000	5,000	1,500	1,000
Custer and Powder River	—	—	37,405	8,450
Daniels	—	1,000	326,000	17,000
Dawson	110,000	26,000	805,000	10,500
Deer Lodge	—	—	—	—
Fergus	117,200	141,200	6,175	3,350
Flathead	—	—	—	—
Gallatin	29,300	12,580	22,500	7,900
Garfield	3,200	4,000	168,500	2,000
Glacier	—	2,000	—	2,530
Golden Valley and				
Musselshell	242,500	105,800	33,000	96,000
Hill	6,000	5,000	60,750	187,200
Jefferson and Madison	—	2,745	2,405	5,900
Judith Basin	9,860	7,700	4,980	25
Lake	9,500	4,700	3,900	15,800
Liberty	7,200	74,000	3,862	880
McCone	—	—	1,021,491	176,199
Meagher	18,960	6,880	3,440	425
Missoula	—	—	—	—
Park	74,500	25,000	12,500	2,000
Petroleum	2,150	3,700	13,200	3,500
Phillips	2,500	12,000	27,150	1,300
Pondera	—	159,307	—	0
Powder River and Custer	—	—	37,405	8,450
Powell	2,250	2,800	—	—
Prairie	270,000	—	805,000	0
Richland	—	50,000	1,359,000	0
Roosevelt	—	—	277,500	30,000
Rosebud	19,500	67,900	92,000	24,500
Sanders	—	—	—	—
Sheridan	6,500	4,300	933,000	27,000
Stillwater	15,000	51,000	2,100	1,100
Sweet Grass	638,800	145,500	9,450	2,120
Teton	15,000	—	3,000	700
Toole	5,000	15,000	6,700	9,000
Treasure	—	—	—	—
Valley	890	12,100	50,100	9,000
Wheatland	5,800	3,000	—	0
Wibaux	182,000	50,000	430,000	283,500
Yellowstone	11,050	35,500	—	0
Totals	2,158,420	1,311,017	6,661,114	1,015,229

highly probable that they were the primary agent in the decimation of the 'hoppers which moved into the State in July.

Twenty-one domestic animals died as a result of eating carelessly exposed bait or bait materials. No serious injury to humans resulted from the campaign.

Figure 4.—Discarded bread mixer converted into bait mixer, Sheridan County.

Grasshopper Situation for 1937-1938

FOR 1937.—The grasshopper survey, carried on in collaboration with the Bureau of Entomology and Plant Quarantine during the autumn of 1936, allowed for the prediction of a moderately heavy infestation over most of the plains area of the State with still heavier infestations along the Continental Divide and in the Yellowstone Valley. Fortunately, the infestation along the divide was held in check by natural factors. The worst affected counties were Blaine, Carter and Fallon, Dawson, Fergus, Golden Valley and Musselshell, Park, Prairie, Sweet Grass, and Wibaux. Drought

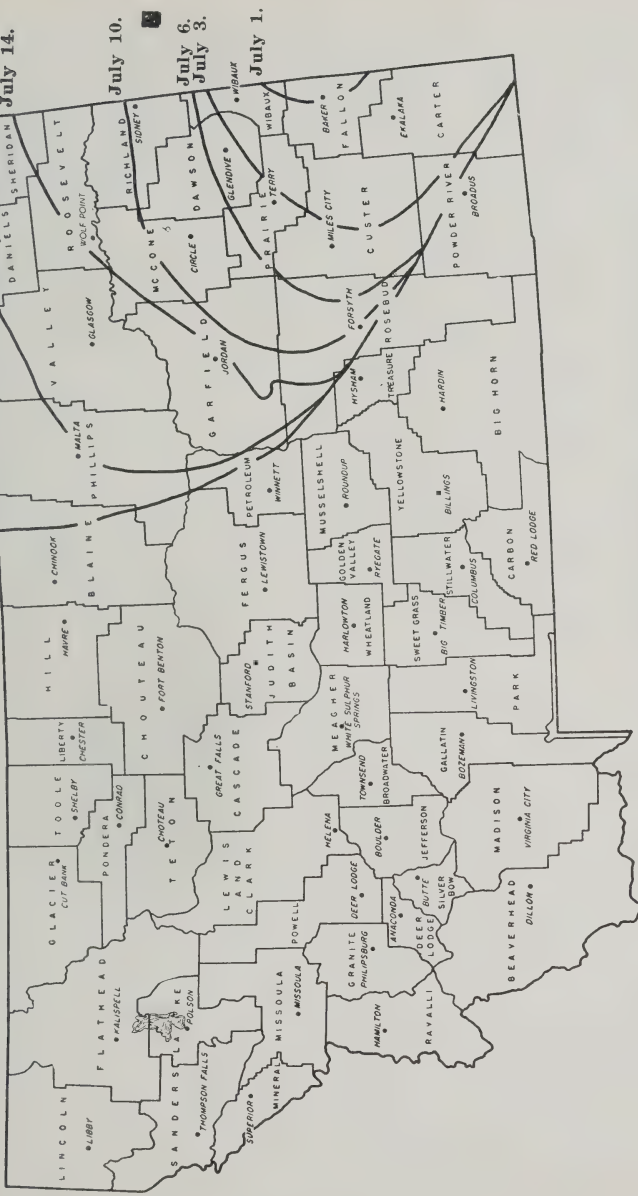


Figure 5.—Map showing the spread of the lesser migratory locust in Montana during the immigration of 1938.

conditions in the northeastern corner of the State seriously affected the campaign in that area. Most of the State suffered from lack of rainfall throughout May, reducing crop prospects and delaying control work. Total losses attributable to grasshoppers in 1937 amounted to $2,196,420.00. Savings, nevertheless, amounted to $1,385,642. The campaign cost $62,753.37, and the savings per dollar spent were $22.08.

FOR 1938.—The autumn survey in 1937 indicated a general reduction in potential injury throughout the State with the exception of the eastern border counties and a few small areas in the center of the State. This prediction was borne out by the resulting populations which appeared during the first half of the season. One bad area in the west, involving parts of Lake, Sanders, and Missoula counties, developed without warning, and a considerable amount of control work was carried on in the northeastern counties bordering North Dakota. The bad areas were reasonably well under control by the first of July, and at that time it appeared that there would be less injury from these pests than for several years past. The final picture, however, was very different.

The Migrations of July, 1938

On the first of July, crop prospects throughout the most of Montana were better than they had been for a decade. On that day, however, Wibaux, Carter, and Fallon counties were invaded by hordes of grasshoppers from the southeast. The species involved was the lesser migratory locust, *Melanoplus mexicanus* Sauss. Where the "native" grasshoppers had been from 2 to 15 per square yard, the migrants increased the population without warning to from 40 to 500 per square yard. By the third of July, they covered all or a part of Carter, Powder River, Custer, Prairie, Dawson, Wibaux, and Fallon counties. From the 4th to the 9th temperatures were generally below 80° and there was little migration. By the 10th, parts of Rosebud, Garfield, McCone, and Richland counties were invaded. Winds were from the northwest on the 12th and 13th, but by the 16th they had continued into parts of Treasure, Petroleum, Phillips, Valley, Daniels, Roosevelt, and Sheridan counties, and on the 17th they appeared in the vicinity of Turner in Blaine County.

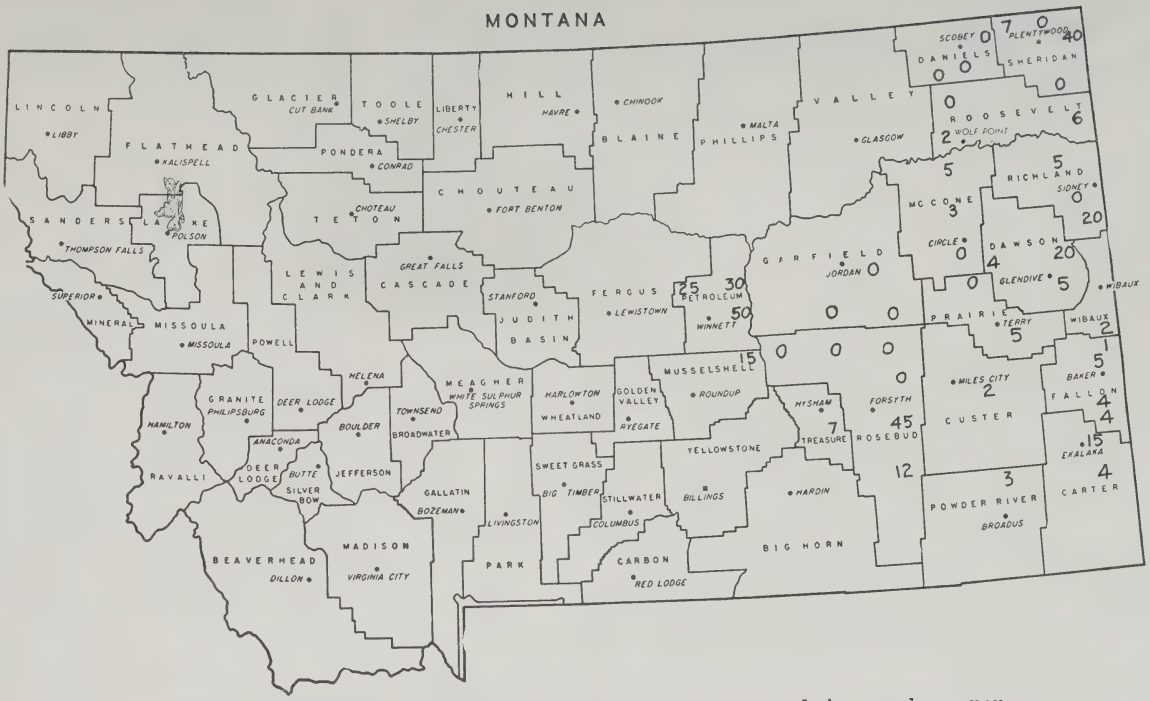


Figure 6.—Infestation of native grasshoppers, expressed in numbers per square yard, just previous to migration. Information from the nymphal survey of the Bureau of Entomology and Plant Quarantine.

This large flight apparently originated in north-central South Dakota and south-central North Dakota. Some of the grasshoppers flew through Montana and far into Saskatchewan. The large migrations took place when the temperature was above 80° and a southerly wind was blowing. Interesting information bearing on this point is recorded by Munro and Saugstad in the Bimonthly Bulletin of the North Dakota Agricultural Experiment Station, Volume 1, Number 1, 1938:

> "The direction of dispersal has ranged from north to northwest from the point of release. A possible explanation of this may be that winds from the south and southeast, being warmer than those from other directions, were more effective in promoting sustained flights of the insects. Records of the United States Weather Bureau reveal that for 15 days of the 29-day period, begnning July 17, winds from the south and southeast prevailed with an average daily maximum temperature of 88.9° F. For the remaining 11 days, which included 7 in July and 4 in August, the winds from the north and northwest prevailed with an average daily maximum temperature of 79° F.—a difference of 9.9° F. lower than the warmer winds from the south. The velocity of the southern winds averaged 7.04 miles per hour while those from the northerly direction averaged 8.1 miles. The heavy flights were generally observed to be travelling with the prevailing winds from the south."

While this temperature difference is doubtless of much importance, it was noticed on several occasions on July 12th and 13th in eastern Montana, that occasional 'hoppers rose some distance into the air and attempted to fly to the northwest, against the wind.

The flights in eastern Montana during the height of the invasion did not appear to be general over the whole area but took the form of large irregular clouds. The maximum elevation at which the migrating grasshoppers flew was not determined, but the following excerpt from a letter received from Mr. M. B. Freeburg, Superintendent of the Eastern Division of the Northwest Airlines, and dated September 1, 1938, is of interest:

> "On July 27, I encountered a large concentrated flight of 'hoppers immediately east of Billings at approximately 7000 feet. It was approximately three miles through the flight . . . . . Mr. Peterson at Billings reports that our Flight 2 of the 26th encountered a flight of 'hoppers at 11,000 feet between Helena and Billings. This is the only accurate and exact information I can give you at the moment, although I might mention that over a period of years 'hopper flights have been

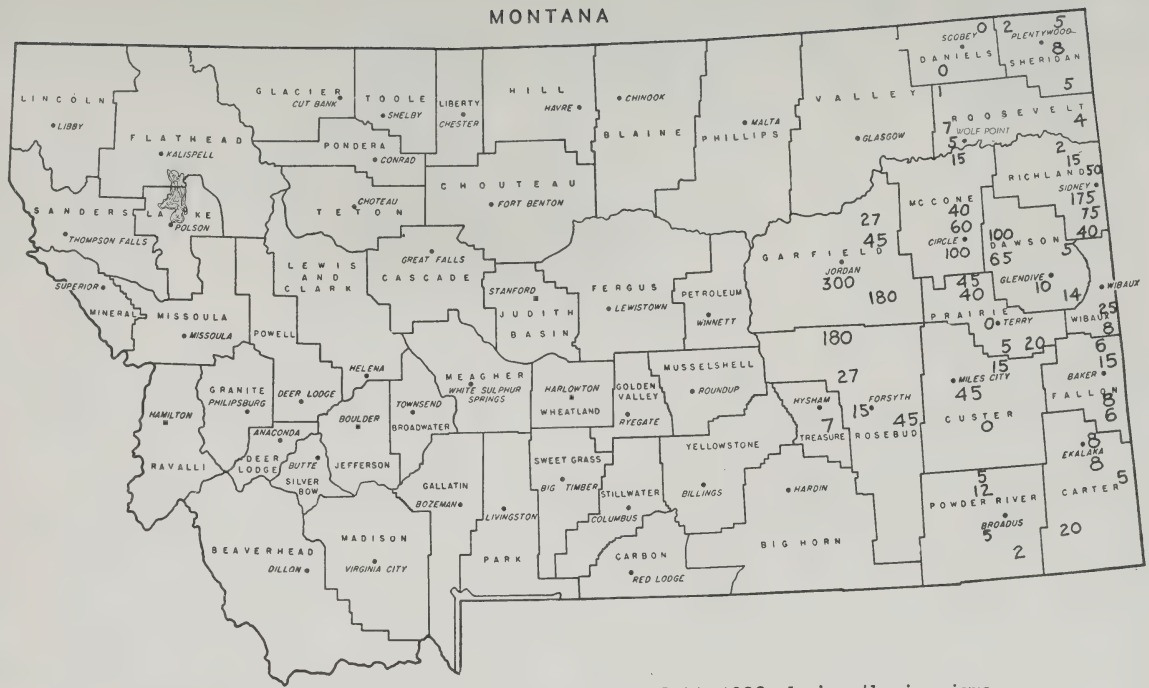


Figure 7.—Infestation figures obtained July 12-14, 1938, during the immigration of the lesser migratory locust.

encountered at all elevations up to and including 13,000 feet by various flights through the summer months."

CROP LOSSES AS A RESULT OF THE MIGRATION.—The 17 counties definitely affected by the immigration were Carter, Custer, Daniels, Dawson, Fallon, Garfield, McCone, Petroleum, Phillips, Prairie, Powder River, Richland, Roosevelt, Rosebud, Sheridan, Valley and Wibaux. The aggregate loss for all of these counties was $6,474,191.00 or an average of $380,835.00 per county.

Thirty-four counties which were affected slightly or not at all by the flight, reported on the grasshopper campaign. The total loss in these counties amounted to $186,923.00 or an average of $5,498.00 per county.

On the basis of the average loss for these 34 counties, a loss of $280,398.00 might have been expected for the State as a whole had not the July immigration occurred. Actually, however, the total loss for the State amounted to $6,661,114.00. Therefore, the loss which theoretically could be charged against the flight was $6,380,716.00. The loss in the counties affected by the flight was 97.2 per cent of the total loss experienced in Montana during 1938.

Crop Savings During 1938

In spite of the large amount of crop damage suffered in 1938, savings attributable to the campaign were comparatively high. A total of $1,007,174.00 worth of crops was saved through the expenditure of $31,004.21, or a savings of $32.49 per dollar spent, as compared with the $22.08 saved per dollar spent in 1937.

TABLE 2.—SUMMARY OF GRASSHOPPER CAMPAIGNS FOR 1937-1938

	1937	1938
Tons of bait used (dry basis)	2,313	1,574
Mixing stations	34	39
Cost of mixing per ton (average)	$4.70	$4.30
Farmers using bait	4,602	3,086
Acres baited	582,904	0
Injury to humans	0	0
Livestock losses	32	21
Federal expenditure	$45,620.25	$24,433.68
State, county, and local expense (exclusive of field labor)	$17,133.12	$ 6,570.53
Total expenditure	$62,753.37	$31,004.21
Savings	$1,385,642.00	$1,007,174.00
Savings per dollar spent	$22.08	$32.49
Losses	$2,196,420.00	$6,661,114.00
Loss per acre injured	$2.01	$2.63

This increase in savings resulted from factors such as the small hatch of grasshoppers, the better growing conditions which may have encouraged better application of the control methods, the more vigorous crops which were able to withstand injury better than in previous seasons, and the allotment of more supervisors to the State by the Federal Government through the Bureau of Entomology and Plant Quarantine.

MORMON CRICKET CONTROL

Mormon Cricket Situation for 1937-1938

FOR 1937.—The Mormon cricket situation in Montana during 1937 was the most serious ever experienced in this State, and probably any other. Forty-five per cent of the infested acreage reported for the nation was in Montana. The infestation affected 976,563 cultivated acres and 6,511,132 acres of range, representing an increase of 59.9 per cent over 1936. The first large-scale control program against these insects was inaugurated in 1937 through the allocation of W. P. A. funds which were administered generally by the Bureau of Entomology, the U. S. Department of Agriculture, and in Montana by the State Entomologist. Large infestations occurred throughout the southern part of the State from Park to Powder River counties. Others appeared in practically all of the mountains east of the divide, and a critical condition developed west of the divide in Lake and Sanders counties. It is doubtful if a single county in the State was without some cricket population in 1937.

This campaign was predominantly successful. While the infestation increased 59.9 per cent and involved much more crop land, the injury sustained increased only 13.8 per cent over the preceding year. The savings amounted to $5,166,098. This figure plus the loss should give the probable loss which would have been sustained had there been no control campaign, or a loss for the State of $5,666,640. The savings plus the losses in 1936 probably amounted to around $500,000. When these two figures are compared, the increase in jeopardized crop acreage is seen to be immense.

Seventeen counties participated in the 1937 campaign: Big Horn, Carbon, Cascade, Chouteau, Fergus, Golden Valley, Judith Basin, Lake, Lewis and Clark, Liberty, Meagher, Park, Sanders,

Stillwater, Sweet Grass, Toole, and Yellowstone.. Besides this, three Federdal agencies participated on lands within the State but under their jurisdiction. These were the Custer National Forest, the Crow, and the Tongue River Indian Agencies.

That the campaign was appreciated was evidenced in various parts of the State. In his final report for Cascade County, County Agent D. P. Thurber stated:

> "It is interesting to note that practically every farmer in the area is fully convinced that the cricket program was directly responsible for all of the crop that was harvested. In other words they said that if there had been no program they would have had no crop. There was not a single man who thought we should not continue with the program next year."

A wheat farmer with extensive holdings in Big Horn County wrote as follows:

> "We believe on our job . . . . we have successfully battled crickets this season, and we estimate our loss from crickets at less than one per cent. Owing to the location of our farms . . . . it is generally conceded that we have successfully combatted the crickets on an area representing two hundred fifty to three thousand acres. In fact, the farmers between our job and Hardin, representing many thousands of acres, did not get into the campaign at all, as our barriers prevented their (the crickets') progress."

FOR 1938.—Control work in 1937 was almost entirely for the protection of crops, and therefore most of the control operations were limited to crop land or areas immediately adjacent to crop land. This affected control work in 1938 extensively, for it was evident throughout the State that where crickets were fought late in the season in 1937 there was a great reduction in the 1938 population. In some areas where control work was not extensive in 1937 there was a reduction from a moderately heavy to a light infestation, indicating that other factors were also at work. In Lake and Sanders counties there was an increase over 1937, and there is evidence of an increase in the extreme northeast counties of the State.

The increase in rainfall of 1938 over 1937 reduced the actual time which could be spent in the fields by the crews, and may have affected the movement of the crickets also.

There were several important changes in the organization and the prosecution of the 1938 campaign. Federal assistance

came from a direct appropriation administered through the medium of the Bureau of Entomology and Plant Quarantine. This allowed a change in the method of obtaining labor. The most costly item in cricket control is the labor involved, and stress was placed on increasing the use of barriers and power dusters. Hand dusters in use decreased from 1,298 in 1937 to 984 in 1938, power dusters increased from 11 to 100, and metal barrier from 54.8 miles to 156. Savings during the 1938 campaign were estimated at $979,345. and losses at $96,304.

It is much more difficult to anticipate possible cricket damage for the next year than is the case with grasshoppers. We are, however, better prepared for a campaign next year than in the past. The following equipment is being carried over for next year's campaign: 40 tons sodium arsenite, 88 tons diatomaceous earth, 4 tons hydrated lime, 110 tons mixed dust, 48,407.5 gallons crude oil, 1,296 usable hand guns, 103 power dusters, and 159 miles of metal barrier. The Federally owned part of this material has been concentrated in a warehouse in Billings and will be reissued to the counties in the spring according to their needs.

TABLE 3.—SUMMARY OF MORMON CRICKET CAMPAIGNS 1937-1938

	1937	1938
Crop savings	$5,166,098	$ 979,345
Crop losses	$ 500,550	$ 96,304
Acres protected	829,930	545,075
Acres injured	211,770	81,836
Crop acres infested	976,563	2,209,078[1]
Range acres infested	6,511,132	5,542,407
Total infested acres	7,487,695	7,751,485
Materials used		
Hand dusters	1,298	984
Power dusters	11	100
Burners	193	—
Mixed dust (tons)	495.35	350.58
Oil (barrels)	1,950.7	4,027
Oil barrier (miles)	135	164
Furrow barrier (miles)	117	3
Metal barrier (miles)	54.8	156
Bait (tons)	771.75	—
Federal appropriation	—	$ 151,578.79
W. P. A. allotment	$ 332,075.20	—
Other Federal agencies	$ 23,652.00	—
State, county, and local	$ 81,154.22	$ 105,652.82[2]
Total expenditures	$ 436,881.42	$ 257,231.61

[1]Includes all land within five miles of crops.
[2]Includes volunteer contributions of $60,905.71.

Effect of Mormon Crickets on Range

No definite information has been available as to the effect of Mormon crickets on the range. Through the increase in funds made available during the past biennium, and with the cooperation of the Bureau of Entomology and Plant Quarantine, and the Forest Service, it was possible to employ Mr. Nolan Keil who made a study of the relationship between Mormon crickets and range plants. The work was carried on in the drainage of Slim Sam Creek, Twp. 6N, R. 1W, above Radersburg. All of these observations were made where precipitation was abundant and the crickets were not forced to eat certain plants because of drought. Further, the crickets migrated to higher elevations before some of the later plants of the lower elevations appeared.

The entire area in which observations were made was between 5000 and 6000 feet in elevation and on a general south and east slope of an open range nature with occasional patches of trees. The trees were both deciduous and evergreen. The most common deciduous trees were *Populus* (cottonwood), *Salix* (willow), and some *Alnus* (alder). The most common evergreens were *Pseudotsuga* (Douglas fir), *Pinus* (pine), and *Picea* (spruce).

The excellent moisture conditions persisting throughout April, May, June and the first half of July increased the normal length of life for many of the more succulent plants. As the crickets preferred many of these to the grasses, this may explain to some extent the small damage to grasses this year.

A collection of 203 species of range plants was made, of which 55 were fed upon by Mormon crickets. Injury to these plants was divided into feeding on leaves and feeding on flowers and seeds.

The 10 plants showing greatest injury to leaves, in order of damage suffered, were: wild onion *(Allium nuttallii)*, nodding onion *(Allium cernum)*, larkspur *(Delphinium bicolor)*, bitterroot *(Lewisia rediviva)*, mouse ear *(Cerastium arvense)*, shooting star *(Dodocatheon conjugens)*, violet *(Viola nuttallii)*, dandelion *(Taraxacum officinale)*, yellowbell *(Fritillaria pudica)*, and yarrow *(Achillea millefolium)*. The first grass to appear in this series was fifteenth in order of injury sustained.

The 10 plants showing greatest injury to flowers and seeds

were, in order: shooting star *(Dodocatheon conjugens),* looseleaf lupine *(Lupinus laxiflora),* mouse ear *(Cerastium arvense),* bluebell *(Mertensia lanceolata),* yellowbell *(Fritillaria pudica),* pussytoes *(Antennaria imbricata),* larkspur *(Delphinium bicolor),* littleleaf alumroot *(Henchera parviflora),* blue bunch wheatgrass *(Agropyron spicatum),* and sedge *(Carex douglasii).*

It may be noted that of the 10 plants showing greatest foliage damage only 4 appear among the 10 showing greatest flower and seed damage. Many of the plants heavily damaged early in the season lived to produce flowers and seeds. Only one species, *Dodocatheon conjugens,* showed more than 38 per cent damage, this occurring early in the season before the crickets had reached the seventh instar. It may be noted also that of the first 10 plants most heavily damaged, only 2, *Agropyron spicatum* and *Carex douglasii,* are especially valuable as forage plants, *A. spicatum* being especially valuable because of its high palatability to all classes of livestock and its resistance to grazing. As for some of the other injured plants, in regard to economic value it may be said that *Allium* (onion) furnishes green succulent herbage early in the spring, which is eaten readily by cattle and sheep. *Delphinium* (larkspur) is palatable to most stock but is known to be poisonous to cattle and is considered objectional to a range. The fleshy leaves of *Lewisia* (bitterroot) were fed upon quite extensively by crickets; in heavily infested areas nearly every plant showed more or less damage. The bitterroot has little or no forage value. *Cerastium* (mouse ear) although heavily fed upon was scarce in this range and of little importance *Fritillaria* (yellowbell), *Dodocatheon* (shooting star), and *Viola* (violet) are short lived and have practically no forage value. *Mertensia* (bluebell) has little forage value to most livestock but is highly palatable to sheep. *Antennaria* (pussytoes) is slightly eaten by sheep but is almost worthless as forage.

The most common forms of damage were for the crickets to either eat on the leaves leaving the larger veins, which in the grasses gave a shredded appearance, or to cut the flower stem off causing the head to fall and then eat down the cut stems.

OTHER IMPORTANT INSECTS OF THE YEARS 1937-1938

PALE WESTERN CUTWORM

(Agrotis orthogonia Morr.)

It has been pointed out in previous reports that the abundance of this pest is directly correlated with the rainfall in May and June of the preceding year. Annually an examination of the weather records for the State is made and the possibility of outbreaks of this pest is ascertained. With this information available it is possible to alter farming practices so as to practically eliminate injury the following year.

The pale western cutworm lays its eggs, approximately between August 15th and September 15th, in worked soil which is without a crust. Therefore, a field which is to be planted to wheat the following season should not be worked between these two dates. Further, Seamans[1] has shown that there is a possibility of eliminating these insects in the spring from infested fields. He has shown that the newly hatched larvae feed on the surface for a period in the spring before going into the ground. They are dependent on green food. Further, they may live for some time without food provided they have not eaten, but once they have taken food they starve quickly when it is not available to them. On the basis of these observations he suggests that fields, in which infestations are expected to appear, be allowed to green slightly in the spring so that the newly hatched larvae may have a chance to feed. The fields then should be cultivated in such a way that no growing plants appear above the surface of the soil *for at least 5 days.* Seeding may then follow and there is a high probability that most of the little larvae will have starved before green vegetation again appears.

Fortunately the weather experienced during the spring of 1938 indicates that injury from pale western cutworm is not likely to occur anywhere in Montana in 1939.

ARMY WORM

(Cirphis unipunctata Haw.)

True army worms have been taken in Montana at Hardin, Havre, Hamilton, Waterloo, Malta, Miles City, Bozeman, Three

[1]Seamans, H. L., Scientific Agriculture, Vol. 17, No. 10: 612-615, June, 1937.

Forks, and Sidney, indicating a general distribution throughout the State. They have appeared in outbreak numbers, however, only twice, first in Big Horn County in 1915, and second in an area centering about Sidney in 1937.

The pest was noticed first in the Sidney area on about the 5th of July, 1937. Some time before, the adults had been seen flying in considerable numbers. The caterpillars hide during the most of the day beneath clods, matted vegetation, and other pro-

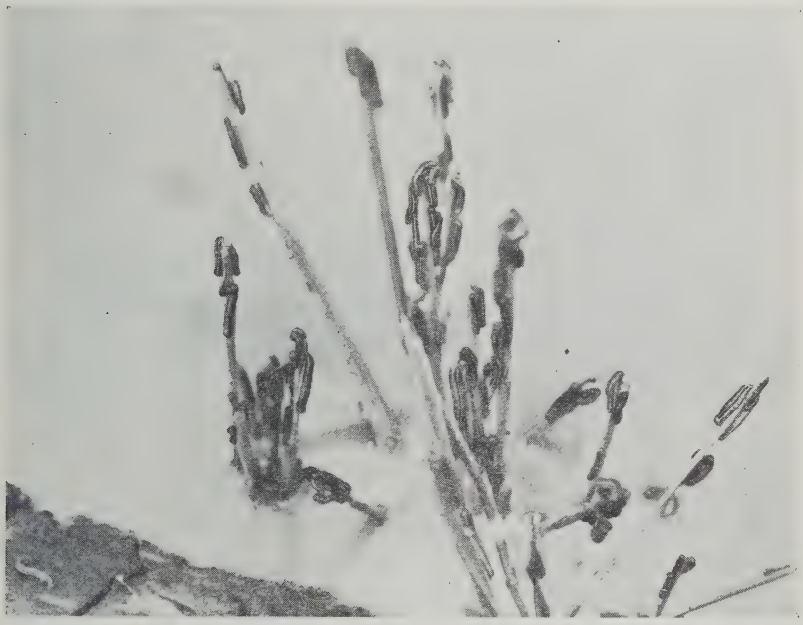


Figure 8.—Army worms (*Cirphis unipunctata* Haw.) at the edge of an irrigation ditch, Richland County, 1937.

tection, coming out toward the middle of the afternoon. They take bait readily in the afternoon when they start to feed.

The methods of control used in the Sidney area in 1937 were:

1. Poison bait spread about 4 p. m. This bait consisted of the following ingredients:

Bran	100 lbs.
Water	12 gals.
Cane molasses	8 qts.
Sodium arsenite	4 lbs.

Comparative tests were run to discover whether the addition of molasses was essential. Although the experiments were insufficient to furnish definite conclusions, the indications were that the addition of molasses was desirable.

2. Where irrigation water was available, a small stream of water running through the ditches served as an excellent barrier.
3. Where water was not available, steep-sided ditches which were kept dusty by dragging a log through them proved good barriers, largely stopping migrations of worms.

SAY'S PLANT BUG

(Chlorochroa sayi Stal.)

While not so abundant this past season as in some previous years, this pest continued to injure wheat more or less in the Triangle Area north of Great Falls. Information is not available as to the total loss suffered in the State during the past biennium. It was estimated that there was a 3 per cent injury to wheat kernels on one farm near Big Sandy. Say's plant bugs were extremely abundant at the North Montana Branch Experiment Station at Havre the last week in July. An examination of range areas was made in the vicinity of the Station at that time and a few bugs were found in areas where the range was poor and Russian thistles and tumbling mustard were invaders. They were extremely rare in these situations, however.

Say's plant bug is most abundant in the spring in weedy fields where the nymphs feed to a large extent on the above weeds. Later in the season they migrate into wheat fields. The present infestation in Montana has just passed its sixth year and shows little tendency to disappear—in fact, large populations have been encountered as far east as Rosebud County and the vicinity of Fallon in Prairie County. It may be that the continuance of the pest in the State is in part at least the result of large acreages of abandoned crop land.

Investigations are under way at the North Montana Branch Station to discover if the shortening of the Russian thistle-tumbling mustard period of the reversion cycle by the planting of abandoned crop land to crested wheatgrass will affect plant bug populations.

SUGAR BEET WEBWORM

(Loxostege sticticalis L.)

The outbreak of sugar beet webworms in 1938 was the heaviest since the state-wide infestation of 1932. In many respects it could be classified as a more severe outbreak than the one in 1932. While most of the damage this year was confined to the Flathead and Bitterroot valleys and an area around Great Falls, in many cases beets were entirely destroyed, which was

Figure 9.—Sugar beet webworm in case.

not the case in 1932. Usually in a moderate outbreak the beets are defoliated, but in time new leaves are produced; thus the damage is due to delaying the growth of the plant. In most cases a lighter crop of beets is produced following such an infestation. No data are available as yet to show the effect of feeding on the sugar content of the beet. In many cases this year both in the Flathead and Bitterroot valleys the beets were entirely destroyed by the worms eating the crown out of the plant. In some fields entire areas were destroyed in this manner, while in others only occasional beets were entirely destroyed.

Contrary to the general rule, most of the eggs were deposited on the plants in the field rather than on bordering weed patches. This may be accounted for by the fact that the adults did not emerge until much later this year, and considerable foliage was present in the beet fields at the time they were

ready to lay eggs. There was a very light second generation.

None of the commonly recommended insecticides proved of much value in controlling the worms when they were present in large numbers.

As a rule only 2 to 5 per cent of the first generation enter the prepupal stage, but a survey made this year showed that from 45 to 50 per cent of the first generation entered this stage. The reason for this large percentage entering the prepupal stage is not known. However, many European workers have noted that such a condition generally precedes a severe outbreak. On this basis, providing conditions are favorable for the production of a high percentage of fertility among females in the spring of 1939, a rather severe outbreak of this insect may be expected.

CUCUMBER BEETLE

(Diabrotica vittata Fab.)

This species has long been recognized as the worst pest of cucurbits throughout America east of the Rocky Mountains. A few specimens were collected in 1932 from Custer County. During the 1938 season the beetles were very abundant in the truck-farming areas of Yellowstone County. They were also sent in for identification from Daniels and Roosevelt counties.

The adult beetles are about 1/5 inch long, with three black stripes down the back separated by wider stripes of bright yellow. They eat irregular holes in the leaves and flowers of cucumbers, squash, melons, and pumpkins. The larvae live in the soil and may damage the roots, although this type of injury has not been noted in the Montana infestations. In some parts of the country the adults carry a serious disease of cucurbits called bacterial wilt. Up to the present this disease has not appeared in association with the beetles in Montana.

Cucumber plants are attacked as soon as they appear above ground by beetles which have overwintered in trash. The most successful control is a repellent and poisonous dust consisting of one part calcium arsenate and twenty parts burned gypsum or land plaster which should be thoroughly mixed and dusted over the plants. The plants should be kept covered with this dust from the time they appear above ground in the spring until the first generation of beetles has disappeared.

CODLING MOTH

(Carpocapsa pomonella L.)

For the past 2 years, bait traps have been used in the Bitterroot Valley for timing the sprays for the codling moth. During the 1937 season the moths were few throughout the most of the Valley, being most abundant northeast of Stevensville. Here the largest number collected from one trap at one inspection was 13. Cover sprays were timed by these trap collections by many of the growers. In 1938 there was a pronounced increase in trap collections. This increase was rather general, at least from west of Hamilton to Stevensville where the greatest

Figure 10.—Codling moth bait trap, Bitterroot Valley, 1937.

concentration again occurred. Here the maximum number of moths collected from one trap at one inspection was 54. Populations indicated by the magnitude of some of the collections of this year are of considerable importance to apple growers.

By means of the traps it is not only possible to time cover sprays, but comparisons may be made, from year to year, as to the upward or downward trend in codling moth populations.

POTATO PSYLLID

(Paratrioza cockerelli Sulc.)

The Potato psyllid (also called the tomato psyllid) was generally present throughout Montana in 1938. This pest appeared on both tomatoes and potatoes, but on the latter a "purple-top" disease caused by the insects greatly increased the damage. Potatoes, especially early varieties, were seriously affected by

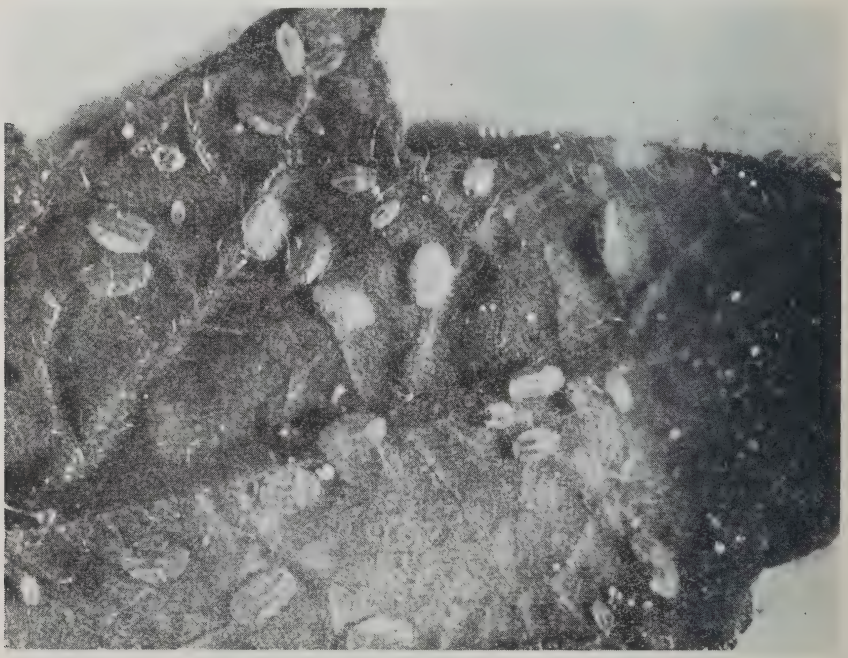


Figure 11.—Psyllid nymphs on tomato leaf. Notice the eggs on the edge of the leaf. Approximately 6 times natural size.

the "purple-top", and produced very small tubers which in many cases did not justify the cost of digging.

The adult potato psyllids are about 1/16 of an inch long and have stout hind legs which enable them to jump when disturbed. They are sometimes called "jumping plant-lice." The females lay tiny oval, orange eggs which are supported on short stalks. Each female may deposite 300 or more eggs. The eggs hatch into tiny, scale-like, wingless nymphs, which feed on the plants, moult five times at 3 or 4-day intervals, and emerge as winged adults. There may be several generations during the summer season.

Experiments carried on during the past season indicate that young psyllid nymphs are easily killed by a lime-sulphur spray, or by various sulphur dusts, but the older nymphs and the adults are more resistant to the action of these insecticides. The use of the standard lime-sulphur spray is therefore successful only when the following conditions are met:

a) Spray must be of the proper strength (1 gal. 33° Baume' lime-sulphur to 40 gallons of water, or equivalent strength).

b) Spray must be forcefully applied to the under surface of foliage.

c) Plants must be sprayed early in the season, before the nymphs have had a chance to produce the "purple-top" disease.

d) Most of the insects should be in the younger nymphal stages, since the older nymphs and adults are not easily killed.

Considerable spraying was carried out by growers in Yellowstone County, but the "purple-top" disease was already too far advanced to permit recovery of the plants.

GRASS PLANT BUGS

(Labops hesperius Uhl. and *Conostethus* n. sp.*)*

In the spring of 1936 two species of plant bugs were noticed attacking range grasses on the Crow Indian Reservation. In the spring of 1938 these pests were again abundant and some invasion of winter wheat occurred east of Crow Agency and south

of Hardin in Big Horn County. Specimens were collected and sent to Dr. H. H. Knight who identified them. The Labops was much more common in wheat than was the Conostethus. Injury was typical and consisted of mottling of the leaves. Where feeding was intense there was a tendency for the leaves to curl longitudinally and wither. The height of the injury to wheat occurred approximately May 24, 1938, after which time the number of bugs decreased and the wheat, which was growing vigorously, outstripped the injury.

Range grasses attacked were *Koeleria cristata* (L.) Pers., *Poa secunda* Presl., *Stipa comata* Trin. and Rupt., *Stipa* (?) *williamsi* Scrbn. and a species which is probably a Hordeum.

LEAF FOLDING SAWFLY

(Pontania bozemani Cooley*)*

Larvae of this insect, prevalent in 1924, were again observed in numbers, folding the edges of cottonwood leaves. Similar damage has been noted as far north as Swift Current, Saskatchewan.

ALPINE ROCK CRAWLER

(Grylloblatta campodeiformis Walk.*)*

Several new collection records, all in Gallatin County, have accumulated for this alpine insect. The first Montana specimens were taken in the Gallatin Range (1936), in southern Gallatin County. Many more specimens have been found at several points in the Bridger Mountains, about 20 miles from Bozeman. Although formerly considered quite rare, this species is now readily found at certain seasons of the year in favorable localities. A recent intensive survey of one area covering 120 square yards yielded 64 specimens.

MAPLE TWIG BORER

(Proteoteras aesculana Riley*)*

Specimens of this insect, the first reported to the Montana Agricultural Experiment Station, were reared from specimens collected in Billings, in July, 1937. They were determined by J. McDunnough.

WOOLLY ELM APHIS

(Eriosoma americanum Riley*)*

This plant louse has been extremely abundant in Montana during the past 2 years. In some areas it has been the limiting factor in the planting of American elms as shade trees. It attacks the elms in the spring, curling and distorting the leaves, and producing honey dew in quantities. In June a winged generation appears and the insects leave the elm leaves and go to the roots of Juneberry. In the autumn they produce other winged forms which migrate back to elms and deposit the overwintering eggs. On September 15th and 16th, 1938, the returning migrants were clustering by the millions on the bark of elm trees in Terry and Malta.

Unless there are hosts other than the Juneberry, the elimination of this alternate host should control this pest. Practically, however, if not impossible, it certainly is not feasible to control this insect in this manner. A thorough dormant spray consisting of a 3 or 4 per cent oil emulsion has given fair results by destroying the overwintering eggs.

TOMATO WORM

(Protoparce sexta Johanssen*)*

It is probable that this pest of tomatoes has occurred in Montana for some time. The first authentic records for Montana, however, were obtained during the summer of 1938. One individual was received from Beaverhead County, and a number of the worms were collected from tomato vines at Three Forks on August 30, 1938.

In gardens, hand picking is the best means of control. In large plantings, dusting with lead arsenate at the rate of five pounds per acre has been recommended in other parts of the country. No dusting should be done for at least 10 days before the tomatoes start to ripen.

LITTLE EARWIG

(Labia minor Linnaeus*)*

This tiny earwig was first collected in Montana at Bozeman, on May 31, 1914. It was not collected again until September 7, 1938, when one specimen was taken in the North Cottonwood Canyon, Gallatin County, while sweeping for grasshoppers.

INDEX

INSECT CONTROL IN MONTANA, 1937-1938 3
Grasshopper Control 7
General conditions during 1937-1938 7
Grasshopper situation for 1937-1938 10
For 1937 10
For 1938 12
Migration of July, 1938 12
Crop losses as a result of the migration 16
Crop savings during 1938 16
Mormon Cricket Control 17
Mormon cricket situation for 1937-1938 17
For 1937 17
For 1938 18
Effect of Mormon Crickets on the range 20
OTHER IMPORTANT INSECTS OF THE YEARS 1937-1938 22
Pale Western Cutworm 22
Army Worm 22
Say's Plant Bug 24
Sugar Beet Webworm 25
Cucumber Beetle 26
Codling Moth 27
Potato Psyllid 28
Grass Plant Bug 29
Leaf-folding Sawfly 30
Alpine Rock Crawler 30
Maple Twig Borer 30
Wooly Elm Aphis 31
Tomato Worm 31
Little Earwig 31

9

7
2

ETIN NO. 384 JANUARY 1941

Montana Insect Pests 1939 and 1940

TWENTY-EIGHTH REPORT OF THE STATE ENTOMOLOGIST

BY

HARLOW B. MILLS, STATE ENTOMOLOGIST

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

Natural History Survey
Library

Bozeman, Montana.
January 1, 1941.

To His Excellency,
Governor Sam C. Ford,
Helena, Montana.
My Dear Sir:

I am pleased to present herewith the 28th report of the State Entomologist of Montana.

The Office of the State Entomologist was established by the Legislative Assembly of 1903 with the assigned duties of conducting field investigations on injurious insects within the State, and of investigating outbreaks of injurious insects and making recommendations for control.

Since the establishment of this office 37 years ago, agriculture within the State has increased greatly, and proportionately more time has been spent by the State Entomologist in carrying out the duties of the office. During the last decade of extensive outbreaks of grasshoppers and Mormon crickets, the major part of his time has been spent in control work.

The law prescribes that the office carry no salary other than that received from the College of Agriculture and Mechanic Arts and the Experiment Station, and twenty years ago this was a reasonable arrangement. At the present time, however, an equitable distribution of salary should include an item for this purpose in the annual appropriation for this office.

Grasshoppers, during the past biennium, have been again the major injurious insects within the State, and have received much attention. It is estimated that out of a possible loss of $37,365,612 to crops because of infestations of 'hoppers and Mormon crickets, a savings of $22,909,265 has been realized because of cooperative control campaigns with the United States Department of Agriculture in the last four years.

It should be pointed out that campaigns against such injurious insects have been made possible only through the assistance of Federal funds. Grasshopper bait materials have been purchased for use in the State, and during the past two years equipment has been purchased and crews hired for baiting on abandoned land. While the figures on total Federal expenditures for grasshopper control during the past two years are not available, of the $163,046.10 spent on Mormon cricket control in 1939 and 1940, $125,042.96 came from Federal funds. Practically all of the remainder came from county and individual sources.

Funds made available by the State were far too small even to care for supervision.

A few newly introduced pests are recorded herein, and mention is made of one which is within striking distance of us in the West.

Respectfully submitted,

HARLOW B. MILLS,
State Entomologist.

MONTANA INSECT PESTS 1939 AND 1940

Twenty-Eighth Report of the State Entomologist

Harlow B. Mills

INTRODUCTION

The years 1939 and 1940 were characterized, as have been all in the decade just past, by intense grasshopper infestations in a large part of the State. These pests again were by far the dominant injurious insects, and their numbers were tremendous.

During the past three years, flights of the lesser migratory locust (*Melanoplus mexicanus* Sauss.) have been one of the outstanding biological phenomena of this region. This species, which is known to have migratory tendencies, has been comparatively quiescent in the State for many years, and the migrations which occurred were of small proportions and for short distances. As was reported in the Twenty-Seventh Report of the State Entomologist[1] the native populations of all species of grasshoppers in the State were at a low ebb in 1938. On the first day of July of that year, immense numbers of the lesser migratory locust invaded the State from the southeast, traveling as far to the northwest as Blaine, Fergus, Petroleum, Rosebud, and Treasure counties. Large numbers of eggs were laid in the east-central area, involving Phillips, Valley, Daniels, Sheridan, Roosevelt, Richland, Dawson, Wibaux, Fallon, Prairie, Custer, Rosebud, Treasure, Garfield, and Petroleum counties. This area was delimited by the survey of the autumn of 1938, and preparations were made to combat the hatching 'hoppers in the spring of 1939. The control operations were complicated by the deposition of large numbers of eggs in idle and reverted lands, and in depleted range which was being invaded by such annual weeds as Russian thistle and tumbling mustard.

To meet this new and unusual condition, the United States Department of Agriculture, through the Bureau of Entomology and Plant Quarantine, instituted a new program, furnishing bait, mixing, transportation, and crews to poison infested, reverted, and range land from which migrations might originate. This was in addition to the usual cropland program in which bait materials were furn-

[1]Montana Experiment Station Bulletin 366, 1939, pp. 12-16. (Out of print. Available only in libraries.)

ished to farmers. The area involved was so large, though, that great numbers of grasshoppers reached maturity and migrated in the fall of 1939 (figure 1).

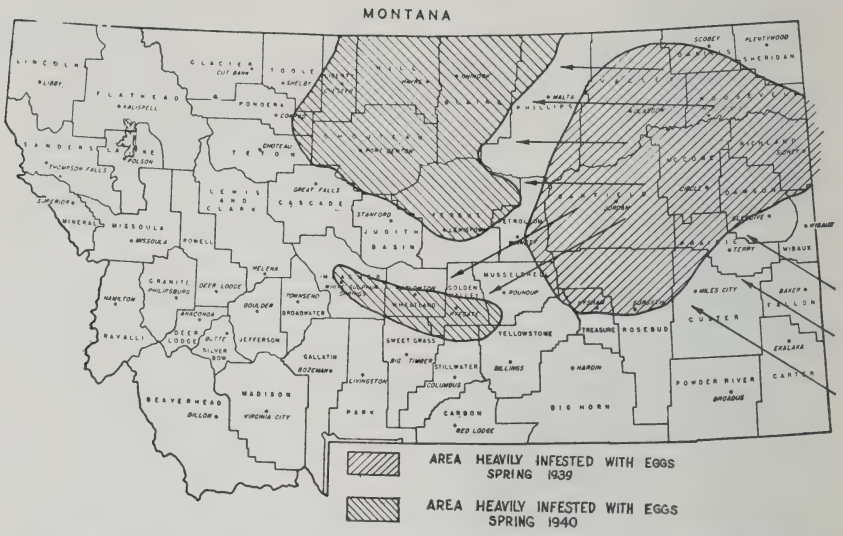


Figure 1. Egg infestations (*Melanoplus mexicanus*) in the springs of 1939 and 1940, resulting from the invasion of 1938. Arrows show direction of flight.

This new migration was primarily to the northwest again, and flying 'hoppers invaded an area as far west at Toole, Pondera, Teton, Chouteau, and Fergus counties. The survey in the fall of 1939 indicated that the area so heavily infested in the summer of that year was now practically devoid of these pests, while an area involving Phillips, Blaine, Hill, Liberty, Toole, Pondera, Teton, Chouteau, and Fergus counties which had received the migration, was heavily infested with eggs. Hill County, which had an infestation of 83 per cent, was the most heavily infested county ever recorded in the country.

Fortunately, practically all of the eggs were laid in crop and idle land, and the range did not present the problem which it did in east-central Montana in the summer of 1939. The special Federal program was again in operation during the 1940 control season but was largely limited to the treatment of roadsides. The hatch in the spring of 1940 was well indicated by the previous fall's survey, but the intensity of the hatch was not forseen.

Migrations commensurate with those of the summers of 1938 and 1939 did not occur during the summer of 1940, although there was a great deal of general movement. The 'hoppers were in a

mood to fly, and did infest parts of Toole, Pondera, Teton, Wheatland, Golden Valley, Musselshell, Rosebud, Petroleum, and possibly Valley, which were not so heavily infested during the summer. This lack of mass flight for considerable distance was probably due to the weather conditions during the flight period, and to the great reduction in populations as a result of the intensive control program.

It is interesting to note that the migration of 1938 invaded an area in which grasshoppers were on the decline and that there were, considering the State as a whole, fewer of them in 1940 than in 1939. They were apparently able to hold up their populations primarily on the strength of the immense numbers present even though conditions were not the best for their increase.

MAJOR INSECT CONTROL PROBLEMS

Grasshopper Control in 1939

The unusual conditions prevailing during 1939 in the badly infested area in eastern Montana were (1) high infestations on depleted range, (2) almost a pure infestation of *Melanoplus mexicanus*, (3) a hatch almost two weeks earlier than was expected, (4) an extremely even hatch, (5) uniformly excellent kills with poison bait, and (6) high local interest in the control campaign. While there was a high incidence of egg predation by bee fly and blister beetle larvae, the large numbers of eggs which remained produced excessive populations. In irrigated valleys the two-striped grasshopper (*Melanoplus bivittatus*) appeared locally in some numbers, and along fence rows and roadsides in Judith Basin and Fergus counties they were moderately abundant. There was very little hatch until May 5th, when a spontaneous hatch occurred in parts of Prairie, Custer, Rosebud, Dawson, McCone, and Richland counties. In surrounding areas the appearance of nymphs was delayed a little. The evenness of the hatch was demonstrated by counts made in the area the fourth week in May. At that time 68.9 per cent were in the second instar, 23.3 per cent in the first, and 7.7 per cent in the third, with over 90 per cent of the eggs hatched. A great deal of rain fell for about three weeks beginning May 19th. The counties east of a line drawn through Carbon and Phillips counties had received 100 per cent of their normal rainfall for the April to August period by the last of July, and most of Valley, Daniels, Sheridan, and Roosevelt counties had received 125 per cent of the normal. Baiting operations were stopped, but conditions were such that some periodic feeding kept most of the 'hoppers alive. Mild migration movements were first noted on the 25th and 26th of June, and they continued until the latter part of July.

In 1937 the big-headed grasshopper (*Aulocara elliotti*) was second only to *M. mexicanus* as the dominant species in the State. In

1938 its numbers along with range species with which it usually associates, were negligible.

Disease was a factor in the reduction of numbers of the two-striped grasshopper, and sarcophagid flies were locally abundant throughout the infested areas.

In spite of crop losses amounting to $2,867,923, the campaign was in many respects very successful. Cooperation among all of the agencies involved was excellent, and the interest of the farm operators high. It is estimated that $6,835,758 in crops were saved as a result of the campaign. Bait usage by counties is given in table 1.

TABLE 1.—BAIT USAGE (DRY WEIGHT) BY COUNTIES, 1939-1940.

County	1939 Tons	1940 Tons
Beaverhead	2.5	3.1
Big Horn	8.1	25.75
Blaine	882.5	2,976.98
Broadwater		2.0
Carbon	.6	
Cascade	110.5	353.0
Chouteau	351.0	3,209.0
Custer-Powder River	573.35	
Daniels	1,342.0	
Dawson	1,838.5	
Fallon-Carter	173.0	43.0
Fergus	252.25	4,786.0
Flathead		19.0
Gallatin	12.25	4.45
Garfield	1,059.9	
Glacier		.75
Golden Valley-Musselshell	34.0	37.10
Hill	160.0	6,810.0
Jefferson		
Judith Basin	135.6	165.05
Lake	39.0	1.0
Lewis and Clark	3.0	25.25
Liberty	20.0	1,483.7
Madison		2.0
McCone	2,437.6	
Meagher	1.45	
Missoula	4.5	
Park		
Petroleum	39.0	.6
Phillips	237.5	536.0
Pondera	58.0	588.0
Powell		1.0
Prairie	740.75	
Ravalli	5.0	
Richland	4,884.0	.5
Roosevelt	5,474.5	40.0
Rosebud	870.0	
Sanders	9.0	
Sheridan	543.0	
Stillwater	2.5	6.50
Sweet Grass	.2	4.75
Teton	71.0	550.0
Toole	120.0	232.0
Treasure	281.0	
Valley	3,599.0	6.0
Wheatland	4.0	8.0
Wibaux	523.5	
Yellowstone	6.0	67.75
Total	26,909.88	21,988.23

Grasshopper Control In 1940

Again in 1940 the dominant species in the State was the lesser migratory locust. It is estimated that an intensive educational campaign, carried on during the preceding winter mainly by county agents, was successful in reaching approximately 7,500 people personally, and the farm operators in the badly infested area in north-central Montana were ready when the hatch began. Little 'hoppers appeared earlier again in 1940 than was anticipated. They were first seen about May 11th, and by the 20th some injury was evident. Nymphs appeared in light soil above Gildford in Hill County before any were noted anywhere else along the upper tier of counties. The rush on the mixing stations was almost explosive, a comparatively large amount of bait materials on hand in the critically infested counties was soon exhausted, and for a short period sawdust was not received in sufficient quantities to supply the great demand. As soon as shipments were adjusted no further trouble was experienced with shortages in bait materials.

Some disease in *M. bivittatus* and *M. packardi* was noticed, and sarcophagid flies were moderately abundant in local areas.

The 1940 campaign was successful in saving an estimated $7,012,763, and losses were estimated to amount to $2,155,631. Other than for a temporary shortage of sawdust mentioned previously, the campaign was comparatively smooth-running, cooperation among all agencies involved was excellent, and the interest of the farmers high in the badly infested area.

Bait usage by counties for the 1940 season is given in table 1.

Preparation and the Success of Grasshopper Campaigns

It has been amply demonstrated during the past three years that the success of a grasshopper control campaign is directly proportional to the preparation for it, both in the field of education and

TABLE 2.—LOCAL CONTRIBUTIONS AND PARTICIPATION, 1939-1940

	1939	1940
Number of mixing stations	57	37
Average weight (wet) per sack	80	80
Counties actively engaged	21	10
Farmers using bait	9,588	5,250
Average farmers per county	457	525
Wet bait used	38,479	32,980
Mechanical bait spreaders	—	2,891
Cropland baited (acres)	1,272,289	2,119,451
Range or pasture baited (acres)	1,021,623	86,558
Estimated losses	$2,867,923	$2,155,631
Estimated savings	$6,835,758	$7,012,763

in maintaining quantities of materials at strategic places previous to the actual field work. In 1938, when there was no warning that the counties in eastern Montana would be invaded, and practically no preparation was made for the influx from the southeast, crop losses for the State were estimated to be $6,831,090, and the savings

about one-seventh of that amount, or $940,924. In 1939 preparations were made in advance for a strenuous campaign, and in spite of difficult complicating factors, the savings were estimated at $6,835,758, and the losses considerably less than half of that amount, or $2,867,923. Again in 1940 there was warning of the possibility of a difficult situation in north-central Montana, and extensive preparations were made to meet the condition. The savings amounted to an estimated $7,012,763, and the losses were less than a third of that amount, or $2,155,631 (table 2).

In order to make preparations to meet such emergencies, the annual grasshopper survey is the most valuable field tool at our disposal. The accuracy of prediction, as to areas involved, has been increasing from year to year. It has been obvious, however, that errors have been large on the basis of predicting the amount of bait which may be used in a county. There are so many variable factors which affect the amount of bait which may be used (weather, intensity of infestation, availability of outside assistance, cooperation of involved agencies, ability of personnel, use of cultural methods, natural control, time and evenness of hatch, flights, species involved, survey adequacy, type of farming, etc.) that wide differences between bait prediction figures and bait usage figures are to be expected.

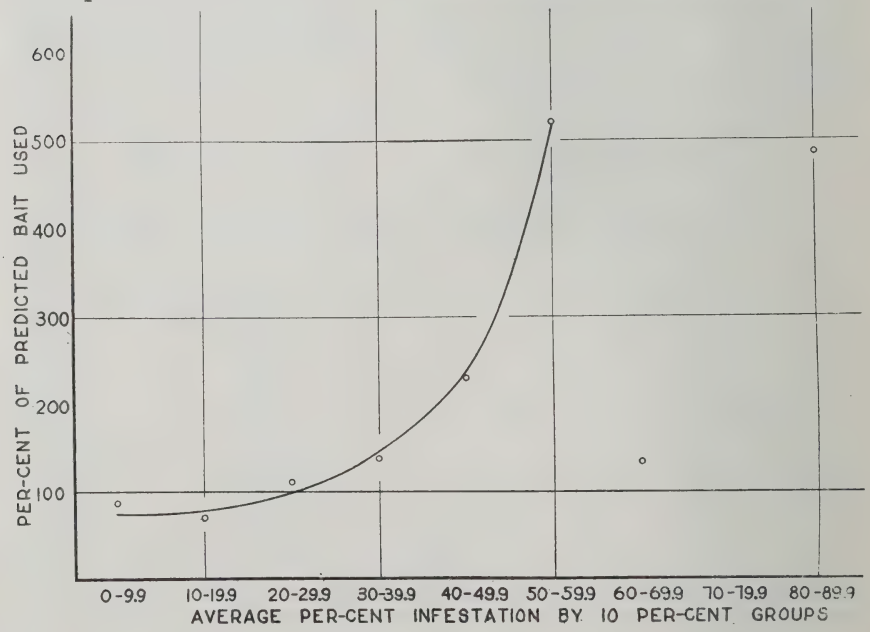


Figure 2. Correlation between percentage of predicted bait used and the intensity of infestation. Montana counties, 1937 to 1940.

During the last two years a general correlation has been noted between the intensity of the infestation and the percentage of the predicted bait which is used. When the per cent infestation (the per cent of cropland which may need baiting) in a country is low, the bait usage is correspondingly low, and when the per cent infestation is high, much more than the predicted amount may be used (figure 2). This general observation led to the compilation of data in an endeavor to ascertain the inclusiveness of this correlation in counties exhibiting all variations in percent infestation. The per cent infestation for all infested Montana counties, together with the per cent of the predicted bait used, was tabulated for 1937, 1938, 1939, and the north-central counties for 1940. The per cent infestations were averaged in 10 per cent groups, and the per cent of predicted bait used, on this basis, is given in the table below:

Per Cent Infestation	No. Times Occurring	Per Cent of Prediction Used
0 to 9.9	17	88.3
10.0 to 19.9	31	70.8
20.0 to 29.9	34	110.9
30.0 to 39.9	14	139.8
40.0 to 49.9	8	231.9
50.0 to 59.9	6	523.7
60.0 to 69.9	1	136.0
70.0 to 79.9	0	——
80.0 to 89.9	1	486.0

The progression calculated in this table appears superfically to be satisfactory until the 60.0 per cent to 69.9 per cent group is reached. This group and the ones following include so few samples that no significance could be attached to them. It is likely that a larger number of samples in the first three groups would bring the percentage of predicted bait which was used lower than those given above.

While there seems to be a good correlation between these two factors when averaged in 10 per cent groups, the data indicate a great deviation on both sides of the mean, and it will take more data than are at hand to put this correlation on a sound basis.

In order to discover the effect of climate and geography on this correlation, the data were compiled for counties west of the Divide. During the period under study these counties consistently used less than the predicted amount of bait regardless of the per cent infestation obtained from the survey.

If this study has a value it will be in allowing an intelligent change in the method of calculating the amounts of bait needed. It should indicate the amount of correction necessary in different ecological habitats infested with injurious numbers of grasshoppers. It may necessitate a division of the chronically infested areas re-

gardless of State lines, and preparations for campaigns may have to be made on such an area basis rather than on a county basis.

Mormon Cricket Control 1939-1940

The period of 1931-1938 marked the most extensive Mormon cricket invasion of crop areas ever recorded in the State. The seriousness of the situation has greatly decreased in the last two years. During 1938 the infestation reached its peak, with an estimated 2,209,078 crop acres and 5,542,407 range acres infested. Most of these 7,751,485 acres were quite thickly populated with crickets. In 1939 there was a decrease of approximately 74 per cent in infested cropland and 43 per cent on the range. In 1940 still another decrease was noted; infested crop areas were reduced 69 per cent and range 38 per cent. Comparison of the peak infestation of 1938 with the condition at the end of the 1940 campaign indicated a two-year reduction of 78 per cent on cropland and 84 per cent on the range, giving a total reduction for all infested acres of 81 per cent (table 3).

TABLE 3.—DECREASE IN MORMON CRICKET INFESTATION 1938 TO 1940

	1938 to 1939		1939 to 1940		1938 to 1940	
	Average decrease acres	% decrease	Average decrease acres	% decrease	Average decrease acres	% decrease
Crop	1,626,258	74	218,800	69	1,845,058	78
Range	1,715,007	31	2,628,300	38	4,343,307	84
Total	3,341,265	43	2,847,100	65	6,188,365	81

Several factors probably are responsble for this decrease in infestation. It is apparent that control work is responsible for a good deal of the reduction. Besides the destruction of tremendous numbers of crickets by the use of dust, bait, and oil and metal barriers, there are indications that when the crickets are disturbed a large number of the eggs which they lay will not hatch. Climatic conditions in all likelihood play an important part, although it is not known what conditions affect the crickets adversely. In past years parasites and predators have been important agents in reducing populations of crickets. In most areas in the State the egg parasite, *Sparaison pilosum* Ashm., has been noted in increasing numbers for several years, and large numbers of parasitized eggs have been collected. The sphecid predator, *Palmodes laeviventris* Cress., has been increasing in numbers, and was very abundant in certain areas in 1940. Field mice habitually dig out the eggs and eat them. In one area where the eggs were concentrated the mice had destroyed 43 per cent of the eggs. When crickets are available, various species of birds feed extensively on them. As many as 53 hawks (probably Swainson's and the red tail) have been seen preying on a single band in Beaverhead County. An examination of regurgitated hawk pellets disclosed a large number of cricket legs, and other indigestible heavily sclerotized parts. Other birds which were no-

ticed feeding extensively on these insects were crows, magpies, sage hens, Brewer's blackbirds, meadow larks, horned larks, and lark buntings. In many cases the bands of crickets could be located by the flocks of birds hovering over them. It has also been observed that coyotes and skunks eat large numbers of the pests.

Control in 1939.—The 23 counties participating in the 1939 campaign were Big Horn, Blaine, Carter, Carbon, Cascade, Chouteau, Custer, Fergus, Gallatin, Golden Valley, Hill, Judith Basin, Lake, Meagher, Musselshell, Park, Phillips, Powder River, Rosebud, Sanders, Stillwater, Sweet Grass, and Yellowstone. The program was on a crop-protection basis with most of the work being done on or within five miles of cropland. In isolated areas, however, crickets were occasionally controlled to rid a county of an infestation. In most of the above counties the program was very successful, and populations were reduced by the campaign and natural factors to such an extent that no control work was necessary in 1940.

Control in 1940.—The 1940 control program was carried out on the same basis as the previous one. There were only five counties involved, Big Horn, Chouteau, Judith Basin, Sanders, and Yellowstone having infestations severe enough to make control work necessary. It is doubtful if control work will be necessary in Chouteau, Judith Basin, and Yellowstone counties in 1941. In the fall of 1940 a large migration entered Beaverhead County from Idaho, and there has been some increase in Meagher County (table 4).

TABLE 4.—MORMON CRICKET CONTROL ACTIVITIES

	1939	1940
Crop savings	$489,215	$99,840
Crop losses	16,280	125
Acres protected	235,885	72,123
Acres injured	13,268	75
Crop acres infested	582,820	364,020
Range acres infested	3,827,400	1,199,100
Total infested acres	4,410,220	1,563,120
Acres dusted	107,207	16,052
Acres baited	4,567	5,663
Equipment and materials used		
Hand dusters	439	92
Power dusters	79	30
Mixed dust (pounds)	516,293	83,301
Mixed bait (pounds)	93,540	108,120
Oil barrier (miles)	114.8	0
Oil (gals.)	36,831	0
Metal barrier (miles)	150.9	3

OTHER IMPORTANT INSECTS OF 1939 AND 1940

Clover Insects

The past two years have been marked by an increase in damage caused by clover insects in the Flathead district, and the damage which they have caused has run into several hundred thousand dollars. The important insects involved were the clover seed midge, the clover root borer, and clover aphids.

Clover seed midge (*Dasyneura legumincola* (Lint.)).—The first and only record of this insect in the State until the present was of an outbreak at Arlee in 1917. In both 1939 and 1940 its attack on red clover in the vicinity of Ronan, Lake County, greatly reduced the seed yield of this important crop. Its attack is characterized by the failure of the florets to open and by the later absence of seed. Tiny pink or orange larvae may be found in the injured clover heads. The winter is spent in the larval stage in the soil. In the early spring these larvae pupate and in May or June emerge as tiny midges which are slate gray with reddish abdomens. The eggs are laid about the calyx and the hatching larvae enter the flowers. When they are full grown they fall to the ground, usually during a period of rain, and complete the cycle. There are usually two generations. To control these insects the clover should be cut a little before the uninjured heads have reached full bloom, and all volunteer clover should be eliminated. This destroys the larvae which would otherwise develop into the second generation of adults, and usually allows ample time for the second growth to produce seed.

The clover root borer (*Hylastinus obscurus* (Marsh)).—This is also present in the Flathead area. The main injury caused by this beetle results from the tunneling of the white, legless larvae in the roots (figure 3). The plants thus attacked wilt, turn brown, and finally die. Although this insect may attack several cultivated legumes, including alfalfa and sweet clover, it prefers red and mammoth clover. This insect does not usually injure stands which are one or two years old, doing the most of its damage to older fields. When any quantity of injury is noticed in the fields, (intense injury is not common), the only control recommended is to plow under the crop.

The clover aphid (*Anuraphis bakeri* Cowen).—This aphid has been abundant in the same area as the two insects discussed above, during 1939 and 1940. Although the plants may not be greatly injured by the feeding of this insect, the seed crop losses may be great because of its secretion of honeydew which mats the heads and cakes the seeds in storage. Close pasturing early in the season or cutting the first crop close to the ground and promptly removing the hay may allow a seed crop to be produced comparatively free from the damage which this insect causes.

Grain Insects

During the last biennium the requests for information concerning the control of insects infesting stored grains have increased considerably over previous years. Although the action of many of those sent in or collected by members of the staff may not actually injure the grain in which they were found, their presence may result

Figure 3. Root of red clover showing tunnels and white larvae of clover root borer.

in dockage when it is sold. Those which have come to our attention recently are listed below:

Granary Weevil (*Sitophilus granarius* (L.)).—This insect, a little smaller than a grain of wheat, is a brownish-black weevil. It is widely distributed throughout the world, and seems to prefer a temperate climate. The little white legless larvae hollow out the inside of the wheat kernels, and may be extremely injurious to stored grains in the State. This pest has been reported from Belgrade, Billings, Brussett, Chinook, Custer, Deer Lodge, East Helena, Flathead County, Fromberg, Hardin, Havre, Joliet, Jordan, Melstone, Miles City, and Plains.

Sawtooth Grain Beetle (*Oryzaephilus surinamensis* (L.)).—This is a slender, flat, light- to dark-brown beetle which is also world-wide in its distribution. The sides of the thorax bear a number of saw-tooth-like projections, from which the insect gets its common name. Both in the larval and adult stages it attacks grain and grain products, but it is not so important a pest as the granary weevil. It has been found in the State in Belgrade, Billings, Bozeman, East Helena, Missoula, and Ronan.

Flat Grain Beetle (*Laemophloeus* sp.).—This is the smallest of the grain-infesting insects which has been found in the State. It is about one-sixteenth of an inch long, flat, elongate, and reddish brown. It apparently cannot live in sound grain, usually following up the damage caused by other grain insects or infesting grain or meal which is out of condition. The genus has been found infesting grain or grain products at Belgrade, Billings, Chinook, Havre, and Hardin.

Broad-Horned Flour Beetle (*Gnathocerus cornutus* (F.)).—This beetle is about one-sixth of an inch in length. It gets its name from the mandibles of the male which extend in front of the head conspicuously and curve inwardly. It is reddish brown in color. It may be found in grain but prefers meal or flour. Although it is found throughout the world, it is comparatively rare in the Great Plains region and in Montana we have a single record from Deer Lodge.

Confused Flour Beetle (*Tribolium confusum* Duv.).—The confused flour beetle is a shiny, reddish-brown beetle, flattened and oval in shape, about one-seventh of an inch long. It is a very general feeder on grain and grain products, and is probably the most important and destructive of the pests attacking flour in the United States. It may be found wherever grain or grain products are stored, especially in flour mills and in homes. We have records of extreme abundance in houses in various parts of the State. It is generally distributed over the world, and has been reported in Montana from Bozeman, Butte, Forsyth, Great Falls, Missoula, Redstone, Turner, and Wolf Point. Accidental ingestion of these pests by humans is not an uncommon occurrence. Investigations recently reported[1] from the Montana Agricultural Experiment Station indicate that cooked confused flour beetles in all stages when consumed in oatmeal are not injurious to humans, even when eaten in rather large doses.

Foreign Grain Beetle (*Ahasverus advena* (Waltl.)).—This tiny, robust, reddish-brown insect seldom if ever attacks clean, dry grain. It is, therefore, not an important pest in stored grain, preferring damp mouldy material and feeding on the moulds present. It is widely distributed throughout the world, but in Montana has been found only at Amsterdam, Custer, and Billings.

[1]Mills, H. B. and Pepper, J. H., J. Econ. Ent. Vol. 32, No. 6, pp. 874-875, 1940.

Mealworms (*Tenebrio molitor* L. and *Tenebrio obscurus* F.).—Of these two large grain insects, the yellow mealworm (*T. molitor*) appears to be more common than the dark mealworm (*T. obscurus*) in Montana. The adults are over one-half of an inch long, elliptical in shape, without the strong body constriction which is noticeable in the cadelle. The yellow mealworm adult is shiny and dark brown to black. The adult of the dark mealworm is similar in size and shape but is dull pitchy black in color. The larvae are elongate, cylindrical, shiny, about an inch long, yellowish in the yellow mealworm and darker in the other species. They breed in refuse grain and coarse cereal and mill products, and are partial to moist situations. There is but one generation a year and, as they feed externally upon grains, they may be easily removed from grain by fanning and screening. The yellow meal worm has been reported from Bozeman, Culbertson, Darby, Dillon, Florence, Great Falls, Hamilton, Hardin, Helena, Joliet, Kalispell, Malta, Miles City, Missoula, and Wibaux. The dark mealworm is known from Bozeman, Great Falls, Hardin, and Hill County.

Cadelle (*Tenebroides mauritanicus* (L)).—One of the larger grain pests, the Cadelle is about one-third of an inch long, oblong, flattened, and black with a conspicuous constriction between the thorax and the abdomen. The larva is chalky white, fleshy, and three-quarters of an inch long when full grown. The tip of the abdomen ends in two dark horns. Both the larva and the adult feed on grain and grain products, and often devour only the germ from the kernel. In Montana there are records of its occurrence in Great Falls and Hardin.

Meal moth (*Pyralis farinalis* L.).—The adult of this pest is a rather fragile looking moth with a wing spread of approximately an inch. The forewings are characteristically marked with deep brown bases and tips, these areas being separated from the irregular intermediate straw-colored stripe by white lines. The underwings are brownish gray, which coloration may be broken into spots toward the hind margin. The whitish larva becomes about an inch long when full grown. It spins a tube as it develops, and trails a silken thread behind it wherever it goes. This webbing is conspicuous in grain which is heavily infested or which has supported this pest for some time. It is a general feeder in grains, cereals, and is sometimes found in hay or other dried vegetable material. It prefers damp materials and is often abundant where grain or grain products are allowed to accumulate. The larvae, which may be tinged with orange at both ends, may gnaw through sacking and cause such materials to spill. There are records in the Montana Insect Pest Survey of its occurrence near Culbertson, Forsyth, Hardin, Kremlin, and in Garfield County.

Mediterranean Flour Moth (*Ephestia kuehniella* Zell.).—The larvae of this small greyish moth may be found infesting accumulations of flour, meal, or waste grain, webbing the material to-

gether. When they are full grown they are about one-half inch long and white or slightly pink in color. Not especially abundant in Montana, this species has been reported from Bozeman, Hardin, Miles City, and Moore.

Indian Meal Moth (*Plodia interpunctella* (Hbn.)).—The adult of this species is a conspicuously marked little moth. The outer two-thirds of the forewings are copper brown, and the inner third is whitish gray. The wings expand to about three-fourths of an inch. The larvae, when fully developed, are about one-half of an inch in length and are dirty white with occasionally a greenish tinge. They web the materials which they infest and may feed on grain, grain products, dried fruits, nuts, and similar food stuffs. They have been reported from Billings and Bozeman in the State.

Control of Grain Insects

Damage from grain insects may be greatly reduced if protective measures are taken to prevent infestations. Bins in which grain is to be stored should be thoroughly cleaned before new grain is stored. New bins should be so constructed that they are off the ground, and that grain cannot accumulate beneath the floor, between walls, etc. Dry grain should be stored, and there should be good ventilation; it is said that grain containing seven or eight per cent moisture is too dry and hard for most insects and that several cannot exist in flour containing eleven per cent or less moisture. Steel or concrete bins are more desirable than wooden structures. Old grain sacks should not be stored near granaries and should not be used again until they have been fumigated or otherwise freed of live insects.

Stored grain which has become infested with grain pests is best treated by fumigation, and carbon disulphide is the most economical and efficient material which can be used for this purpose. This compound is a colorless, rapidly evaporating liquid, which is approximately one-fourth heavier than air (1.26:1). If properly applied to the top of a bin it penetrates downward, killing the insects without injuring the grain. It should be remembered that *carbon disulphide is inflammable and under certain conditions explosive.* Even lighted cigars or cigarettes should be kept away from a building being fumigated with this material. The bin to be treated should be made as tight as possible, and one pound of carbon disulphide should be used for every 100 cubic feet or 80 bushels of grain. Shallow pans may be imbedded in the surface of the grain and the liquid poured into them and allowed to evaporate, or it may be poured over old sacks or blankets thrown into the bin. Fumigation should not be attempted at temperatures below 60°F. U. S. D. A. Farmers' Bulletin 1483 gives further information on this subject.

MISCELLANEOUS RECORDS AND OBSERVATIONS

Say's Plant Bug (*Chlorochroa sayi* Stal).—This bug has been attacking grain crops primarily in north-central Montana every year since 1932. Its attacks have fluctuated in intensity and in localities involved from year to year, sometimes being very destructive locally. Other than in the Triangle area, where it was first noticed in injurious numbers, and where it has been a problem ever since, it has been seen damaging wheat south of Hardin, on Rosebud

Figure 4. Eggs of Say's plant bug on Russian thistle, the common spring host for this pest. Enlarged about 3 to 4 times.

Creek in Rosebud County, and near Savage. This insect overwinters in the adult stage beneath mats of weeds, straw, etc., and has a spring generation primarily on Russian thistle and tumbling mustard. Anything which can be done to destroy the hibernating quarters will reduce the overwintering populations, and an effort should be made to return to grass reverted fields upon which annual weeds are growing (figure 4).

Grass Plant Bugs.—But one instance of movement of the grass plant bug (*Labops hesperius* Uhler) into wheat has been observed

during the past two years. In 1939 these insects invaded a wheat field on Reece Creek north of Bozeman, causing the usual mottling of the leaves. The wheat was about eight inches high at the time, and soon outgrew the damage. *Conostethus americanus* Knight has not been reported as injurious since 1938.

The Potato and Tomato Psyllid.—A survey was made June 19-27, 1939, of all Montana potato areas except those in Flathead and Lake counties. Specimens of *Paratrioza cockerelli* (Sulc) were collected in Lewis and Clark, Cascade, Blaine, Phillips, Valley, Richland, Dawson, Custer, Rosebud, Yellowstone, Carbon, and Stillwater counties. Despite the presence of psyllids at this early date, the subsequent 1939 psyllid losses dropped far below those of 1938. In many parts of the State light psyllid infestations were obscured by heavy Rhizoctonia infections which were very prevalent. However, slight potato losses directly attributable to *Paratrioza cockerelli* were observed at Trident in Gallatin County, at Malta in Phillips County, and in the Yellowstone Valley (Park City, Billings, Huntley, Custer).

A survey was made June 22-27, 1940, of potato plantings in the eastern two-thirds of Montana. Neither adults nor immature stages of *Paratrioza cockerelli* were found west of a line connecting the western borders of Phillips and Yellowstone counties. Adult *Paratrioza cockerelli* were collected in Phillips, Valley, Richland, Dawson, Custer, Rosebud, Big Horn, and Yellowstone counties. Subsequent summer observations of infestations in Yellowstone County showed a gradual increase in populations of psyllids until harvest time, afer which a general migration occurred to tomatoes, egg plant, and peppers. Slight losses in potato yields, unnoted by growers, probably resulted from these infestations. A few farmers sprayed their potatoes (1 gal. liquid lime sulfur testing 28° Baume, in 35 gallons of water) early in the season as a precautionary measure. No reports of psyllid damage were received from growers in the State.

Pear Psylla.—The pear psylla (*Psyllia pyricola* Forst.) is a small, pale-orange to reddish-brown sucking insect. It is one of the most important pests of the pear. When abundant, the leaves turn brown, the fruit drops prematurely or is of poor quality, and both the leaves and fruit may be covered with sticky honeydew which the insects produce. This insect was introduced into Connecticut from Europe in 1832 and has spread over the eastern states. Recently it was introduced into the Spokane area in Washington, and it now presents a threat to the western part of Montana at least. Ravalli, Missoula, Lake, Flathead, and Sanders counties were surveyed from July 23rd to 30th to discover whether or not the insect had reached the State. The following is a tabulation of the results of the survey:

County	No. premises examined	No. trees by variety			No. times psylla collected
		Bartlett	Flemish	Unknown	
Ravalli	34	56	3	74	0
Missoula	11	21	26	9	0
Lake	13	53	61	18	0
Flathead	3	0	12	5	0
Sanders	12	11	1	10	0
Total	73	141	103	116	0

It is likely that this insect does not at present exist in the State. Any of the symptoms mentioned above occurring on pears should be reported and specimens sent immediately to the State Entomologist, Bozeman, Montana.

Lettuce Root Aphis.—During the first week in August 1940, a report was received of injury being suffered by a large planting of head lettuce in the Gallatin Canyon. An examination of the field revealed a large population of root lice attacking primarily the second planting. This insect was identified through the kindness of Miss M. A. Palmer as *Pemphigus bursarius* Linnaeus. The planting most heavily attacked was practically a complete loss; the rest of the field was heavily irrigated for some time after the discovery of the insects, and, although they were present on the last two cuttings, the damage noticed was small.

Spruce Gall Lice.—Cooley's spruce gall louse (*Adelges cooleyi* Gill.) is abundant throughout the State both on native and ornamental trees. There seems to be an individual susceptibility in stands of Engelmann spruce (*Picea engelmanni*), some trees being heavily infested, and others close by practically immune. It has been noted further that black hill spruce (*Picea glauca albertiana*) and Norway spruce (*Picea excelsa*) are more heavily infested than native forms. Another spruce gall aphis (*Pineus pinifoliae* (Fitch)) was found attacking Engelmann spruce at the head of Squaw Creek, Gallatin County, June 26, 1940, at an elevation of approximately 9000 feet. The terminal gall caused by this insect differs from the gall of Cooley's spruce gall louse in being composed of flat scales, giving it a cone-like appearance. (See figure 5). This species has not as yet been recorded as damaging ornamentals in the State.

Although research on the control of the spruce gall louse in Montana is not complete, good control has been obtained in other parts of the country. A spray consisting of one quart of 40 per cent nicotine sulphate and five gallons of miscible oil to 200 gallons of water has been found to be satisfactory. The spray is applied in the spring when the young are hatching from the cotton-covered egg masses and colonizing the new growth.

Striped Cucumber Beetle.—This pest of cucurbits (*Diabrotica vittata* (Fabr.)) was neither reported nor collected in 1939, although in 1938 distribution included Daniels, Roosevelt, and Yel-

Figure 5. Spruce gall aphis (*Pineus pinifoliae* (Fitch)) on Engelmann spruce. The galls on these twigs, shaped like cones, are caused by the feeding of the aphids at the base of the needles on the new growth. The cottony mass near the base of the left twig covered the eggs previous to hatching. In the gall on the right can be seen the adult insects at the bases of the scales. Galls enlarged 1¼ times.

lowstone counties. No cucumber beetles were noticed in 1940 until three specimens were swept from pepper and egg plants near Billings in September and October. On Ocober 24, 1940, hundreds of specimens were collected in a cantaloupe patch near Billings. They were feeding on mellow cantaloupe, gouging sizable holes in fruit which had passed a salable condition. (See figure 6). From one to two dozen beetles were commonly found on single cantaloupe, while fruit nearby might show no damage. Operators of this truck garden had noted no beetles nor damaged cucurbits earlier in the season.

Figure 6. Striped cucumber beetles attacking over-ripe melons.

Strawberry Root Worm.—Following an inquiry on August 8, 1940, from the horticultural inspector at Billings, a strawberry planting west of that city was examined for insects. About 20 per cent of the several hundred plants in this field were dead. The root system of the dead plants had suffered from the feeding of some insect, while leaves of many living and dead plants had been riddled by a chewing insect. Examination of the soil under the dead plants revealed many small white grubs (about one-sixth inch long), numerous pupae, and several small coppery beetles. Most of these adults had four rather irregular, but distinct, black

blotches on the wing covers. These specimens proved to be stages of the strawberry rootworm (*Paria canella* (Fabr.)) previously unreported from Montana. A search in three additional strawberry patches in this area revealed this pest in two of the three plantings.

According to Essig[1] these insects overwinter as adults in the soil, coming out in April and May to feed and deposit eggs on or near the strawberry plants. Larvae hatch from these eggs in seven to fifteen days and feed on the strawberry roots. While Essig notes two generations per year in California, adult emergence dates in the latitude of Billings would suggest a single generation.

When adults are feeding in the spring and autumn, spraying with four pounds lead arsenate to 100 gallons of water gives good control, although this remedy cannot be applied close to picking time. At such periods the plants may be dusted with a mixture of sulfur and ground derris root, containing one per cent rotenone when applied to the plants.

Red Turnip Beetle.—The red turnip beetle (*Entomoscelis adonidis* (Pallas)) is a moderately large beetle, about one-third of an inch in length. In shape it somewhat resembles the Colorado potato beetle, but it is predominantly red with dark areas on the head and pronotum, and three dark stripes on the wing covers. It feeds at night on cabbages, radishes, turnips, and other related plants. Its range extends from Europe through Siberia into the northern part of North America. Although it has been found in the Bridger Mountains, Glacier Park, and at Lombard, it was not reported as injurious until the summer of 1940, when it damaged gardens in and around White Sulphur Springs. It should be controlled easily by the use of usual stomach poisons such as lead arsenate.

Soft-winged Flower Beetle.—This little beetle (*Malachius aeneus* (L.)) was first found in Montana at Bozeman in the spring of 1938 and in 1940 it was not uncommon; a specimen was taken in Madison County near Pony, in the summer of 1940. It is about one-fifth of an inch long, most of the head and prothorax, a V-shaped area including about two-thirds of the elytral suture, the under parts, and the appendages are an irridescent greenish black. The face, the prothorax laterally, and the most of the elytra are deep red. The species was identified by Mr. H. S. Barber of the Bureau of Entomology and Plant Quarantine who submitted the following statement:

"Such a large, conspicuous and abundant exotic species, spreading across our wheat areas, should have received some attention, but except for records of capture in a few places, there seems to be very little information which I can find. It is abundant in

[1]Essig, E. O., Insects of Western North America, 1926, pp. 468-469.

Europe and was reported in New England about 85 years ago, but the only biological notes I find seem based upon the old note by Perris 1852 describing the predatory larva. There is, however, a little-known report that the adults feed upon the soft parts of blossoms of wheat and much reduce the number of kernels formed in a head of wheat, the injury being noticeable only by feeling the ripened heads between the fingers to detect absence of kernels.

"The role of this species in the United States should be determined by new observations on its habits, both as the phytophagous adults and as the predatory larvae."

Alfalfa Weevil.—There are several old records of the alfalfa weevil (*Phytonomus posticus* (Gyll.)) in the State. They were collected from hay shipped into Montana from 1912 to 1914 at Ballantine, Billings, Butte, and Great Falls. In 1938 and 1939 scouts for the Bureau of Entomology and Plant Quarantine collected a few larvae in the vicinity of Wyola. This is the only place in the State where these insects apparently have been established.

Sugar Beet Webworm.—Only light to moderate infestations of the sugar beet webworm (*Loxostege sticticalis* L.) were reported during 1939 and 1940. A heavy moth flight took place over most of the State during early June 1939, but due to the high per cent of sterility among the females few eggs were laid. Moderate infestations necessitating spraying were reported from the vicinity of Fromberg and also from the lower Flathead district near Ronan. Relatively few fields were attacked and damage was slight. In 1940 the moth flight was considerably smaller than during the previous year. The only report of numbers sufficient to require spraying was from the vicinity of Valier. A few fields in the Billings district were reported infested, but not in sufficient numbers to warrant spraying.

Alfalfa Semi-Looper.—This looping, aerial cutworm (*Autographa californica* (Speyer)) was last abundant throughout the State in 1914. The only other record of the species until this year was from Twin Bridges in 1922. In 1940 larvae were reported from alfalfa fields near Helena, Logan, and Ronan, and a large number of adults were flying at Bozeman during the first part of June. The larvae are cutworm-like, but move with a looping motion similar to measuring worms. They are very general feeders, but the most of their damage has been reported from alfalfa. As a usual thing they are so thoroughly held in check by parasites and disease that they are not injurious to crops.

Army Worm.—The true army worm (*Cirphis unipuncta* (Haw.)) appeared in 1940 in a small area south of Scobey. This insect may be a very serious enemy of many crops, especially grasses, but in Montana it becomes sufficiently abundant to do damage only on rare occasions. It may be held in check by the use of grasshopper bait or barriers placed before migrating bands.

Pale Western Cutworm.—The State has experienced several years now with no outbreak of the pale western cutworm (*Agrotis orthogonia* Morr.). It was last important in the spring of 1937. The abundance of this pest is dependent on the rainfall during May, June, and July of the previous year, and it is possible to predict in advance the areas where injury may be expected. Weather data for the spring of 1940 would indicate that it may be a minor pest during 1941 in the Yellowstone Valley from Forsyth to Livingston, and in Golden Valley, Musselshell, central Liberty, southern Lewis and Clark, and Beaverhead counties. Control measures for this insect have been discussed recently[1] and will not be repeated here.

Codling Moth.—In the apple districts of western Montana the codling moth (*Carpocapsa pomonella* (L.)) increased markedly in 1940 over any previous year. Average catches of moths in bait traps went as high as 75.8 for a two-day period. For the first time this pest became sufficiently abundant in the Bitter Root and parts of the Flathead Valley to become one of the foremost problems of the apple orchardist. Conditions during June, July, and August were ideal, and even with good spraying programs the loss was fairly high. However, properly executed spraying programs very decidedly paid for themselves even under conditions of a short crop. The use of bait traps for the collection of adults as an indication of the timing of the cover sprays is becoming more important, and investigations into their use are being continued by Mr. Wm. R. Forsyth, graduate assistant, who was stationed in the area in 1940.

Termites.—Two species of termites have been found in Montana, the damp wood termite (*Zootermposis nevadensis* (Hagen)) which has been collected near Hamilton and doubtless has a wider distribution west of the Divide, and the barren-land subterranean termite (*Reticulitermes tibialis* (Banks)). This latter species (figure 7) is widespread in the State and occasionally damages buildings. It has been collected in or near the following cities in Montana: Billings, Hardin, Havre, Helena, Jefferson Island, Kalispell, Miles City, Powderville, Terry, and Whitehall. The workers, soldiers, and wingless sexual forms are found in tunnels in wood which have been excavated by the workers. This species is not a major pest in the State, but occasionally it is extremely injurious in dwellings. Its presence is usually first noticed because of a buckling or the appearance of holes in the floor, or the swarming of slate-colored winged adults in the rooms. Houses as far north as Havre have been attacked by this insect. Much has been published on the control of the termite and on the prevention of its entrance into houses. Information can be obtained by writing to the Montana Agricul-

[1]Mont. Agr. Exp. Sta. Bul. 366, p. 22, 1939; Mont. Ext. Ser. Bul. 176, p. 16, 1939.

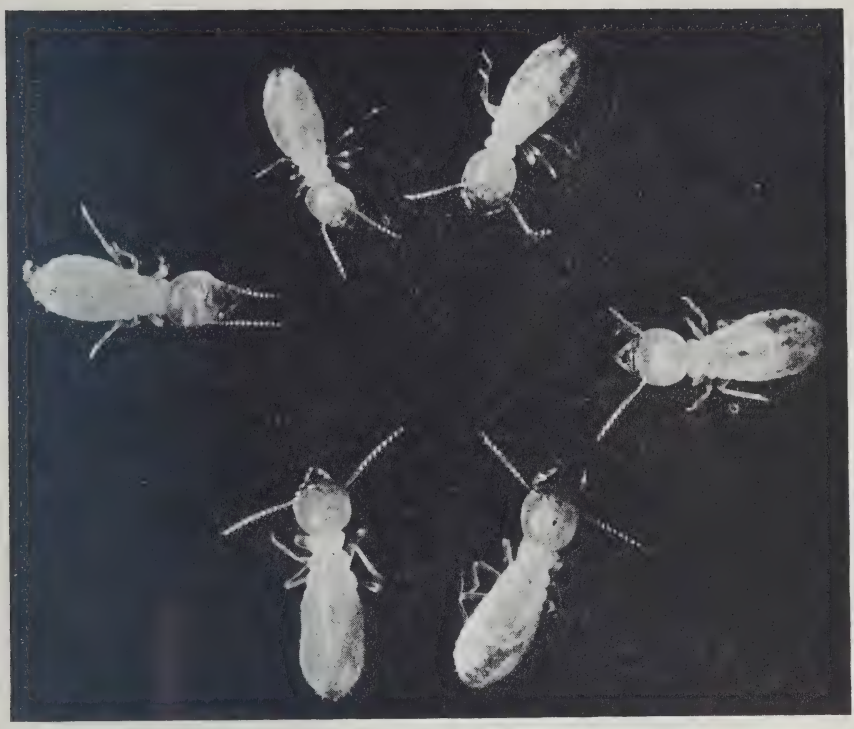


Figure 7. Workers of the termite *Reticulitermes tibialis* Banks. Enlarged 7 times.

tural Experiment Station or to the Office of Information, Department of Agriculture, Washington, D. C.

Alpine Rock Crawler.—Continued search during 1939 and 1940 for this alpine insect (*Grylloblatta campodeiformis* Walker) has yielded some interesting negative and positive collection data. Attempts to collect Grylloblattids in the Bridger Range (Gallatin County) on August 21, September 2, and September 10, 1939, were unsuccessful. Specimens were found in the same general area on September 24, 1939. After the onset of cool autumn weather, accompanied by fall showers, many specimens have been collected in the Gallatin and Springhill canyons. In the Gallatin Canyon on October 11, as well as in the Springhill area on October 17, 1940, a pair of mating adults was found.

Earwigs.—There are no native earwigs in Montana, but two species have been introduced. The little earwig, *Labia minor* L., has been collected twice in or near Bozeman on widely separated dates, and is of little economic importance. In 1939 the European

earwig, *Forficula auricularia* L., was first reported from the State when specimens were collected at Thompson Falls, (figure 8). The abundance of this pest when first discovered would indicate that it had been present for some time previous to 1939. In 1940 an infestation was reported from Lewistown, with the note that these insects had been present for at least six years in this area.

The European earwig is an elongate, shiny brown insect, and is easily identified by the large slender pinchers which are appended to the tip of the abdomen. It is primarily nocturnal in its habits, hiding beneath bark, chips, and other debris during the day. Our infestations undoubtedly came from the introduction of this pest into Pacific ports some time ago. It is abundant in parts of Washington, Oregon, California, and Idaho to the west.

Figure 8. European earwig. Male on left, female on right. Enlarged 5 times.

This insect may be best controlled by the use of poisoned bait. The bait recommended by the Oregon Agricultural Experiment Station, which has worked satisfactorily, consists of

Bran	12 lbs.
Sodium fluosilicate	1 lb.
Fish oil	1 qt.

The dry materials should be thoroughly mixed together and the fish oil added and mixed in. No water is necessary. Sodium fluoride, barium fluosilicate, or paris green may be substituted for the sodium fluosilicate, but they are not so satisfactory. The bait should be scattered about fences, piles of boards, wood piles, trees, and other places where the earwigs may hide. It should be kept away from children. Chickens and other birds would have to eat a great deal of it to be injured.

INDEX

Page

INTRODUCTION 3

MAJOR INSECT CONTROL PROBLEMS 5

Grasshopper Control in 1939 5

Grasshopper Control in 1940 7

Preparation and Success of Grasshopper Campaigns 7

Mormon Cricket Control 1939-1940 10
Control in 1939 11
Control in 1940 11

OTHER IMPORTANT INSECTIONS OF 1939 AND 1940 11
Clover Insects 11
Clover seed midge 12
The clover root borer 12
The clover aphid 12

Grain Insects 12
Granary weevil 13
Sawtooth grain beetle 14
Flat grain beetle 14
Broad-horned flour beetle 14
Confused flour beetle 14
Foreign grain beetle 14
Mealworms 15
Cadelle 15
Meal moth 15
Mediterranean flour moth 15
Indian meal moth 16
Control of Grain Insects 16

MISCELLANEOUS RECORDS AND OBSERVATIONS 17
Say's plant bug 17
Grass plant bugs 17
The potato and tomato psyllid 18
Pear psylla 18
Lettuce root aphis 19
Spruce gall lice 19
Striped cucumber beetle 19
Strawberry root worm 21
Red turnip beetle 22
Soft-winged flower beetle 22
Alfalfa weevil 23
Sugar beet webworm 23
Alfalfa semi-looper 23
Army worm 23
Pale western cutworm 24
Codling moth 24
Termites 24
Alpine rock crawler 25
Earwigs 25

.7
6
9
.2

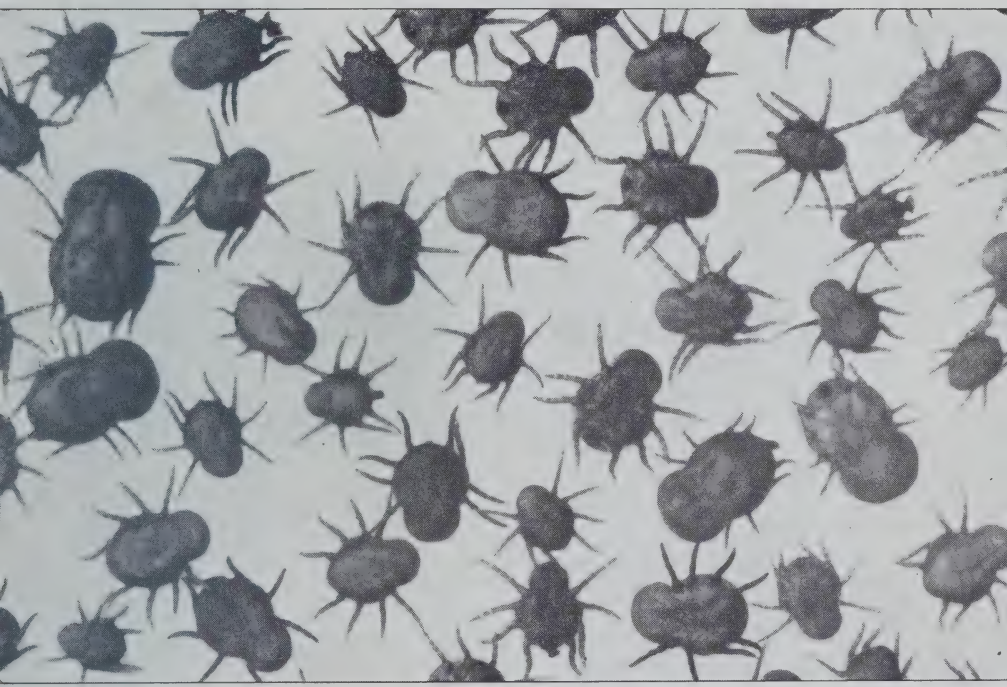
.ETIN NO. 408 DECEMBER, 1942

Montana Insect Pests, 1941 and 1942

TWENTY-NINTH REPORT OF THE STATE ENTOMOLOGIST

BY

HARLOW B. MILLS, STATE ENTOMOLOGIST



SPINOSE EAR TICKS. SEE PAGE 15.

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

Natural History Survey
Library

Bozeman, Montana
December 1, 1942.

To His Excellency
Governor Sam C. Ford
Helena, Montana
My Dear Sir:

I am presenting herewith the 29th Report of the State Entomologist of Montana.

The main work of this office deals with protection of crops from injurious insects. In some respects we have been rather fortunate during the past biennium. Mormon cricket infestations have dropped until these pests are of only local interest in a few areas. No widespread grasshopper infestations were present in 1941 and 1942, although some areas developed critical populations. On the other hand, the east slope of the Rockies and the Yellowstone Valley show a considerable increase in possibilities for grasshopper injury in 1943. Coupled with this will be difficulties in obtaining adequate labor, transportation for materials, etc. which will make next year's campaign more difficult than any in the recent past.

Bee inspection was reestablished, after a cessation of eight years, in this office. The first summary of this work is submitted with this report, and I should especially like to call it to your attention. Considering the fact that it started in the spring of 1941 without implementation, personnel, or established policy we are gratified with the large amount of work accomplished.

Respectfully submitted,
HARLOW B. MILLS
State Entomologist

MONTANA INSECT PESTS 1941 AND 1942

Twenty-ninth Report of the State Entomologist

HARLOW B. MILLS

INTRODUCTION

The insect pests which plague the rancher and farmer in Montana present an ever-changing picture. This is true for at least two reasons. First, the pests of importance are likely to change from year to year, the dry years having their more or less typical complex of injurious forms, and the wet years reducing some of them and making conditions favorable for a new group; further, new pests are appearing in the State bringing with them new problems. Second, in the light of new research findings better control methods are being developed, both in Montana and outside of the State, which necessitate the constant inspection and revision of the approved methods of control. The control of grasshoppers and Mormon crickets is a good example of this. The last decade has seen many advances in our methods of attacking these problems. Survey methods have been developed and refined, bait formulae have been improved and reduced in cost, and the mechanics of mixing and spreading baits have taken great strides forward, largely through the efforts of the United States Bureau of Entomology and Plant Quarantine.

The main efforts of this office have been directed toward the control of the major pests, either through the administration of field control campaigns, or through the preparation of circulars describing approved methods of insect control. More than 300 inquiries on the control of a great variety of harmful animals are received and answered annually.

During the past year 44 single-page pamphlets, many of them illustrated, were prepared by this office and published by the Montana Extension Service. These circulars, Series A, Nos. 1 to 44, are available from County Agents or from the Montana Extension Service, Bozeman, Montana.

Over a period of years the involved states in cooperation with the Bureau of Entomology and Plant Quarantine have developed a good organization for the large-scale control of regional insects of migratory habits. Control operations in Montana, under the joint direction of the State Entomologist's Office and this Bureau,

have involved the suppression of grasshoppers, Mormon crickets, and to a lesser extent the army cutworms. During the past two years Mr. O. B. Hitchcock, Assistant State Entomologist, has taken over most of the direct field supervision. These campaigns have met with considerable success, but as pointed out later in this report, losses actually may be greater during light infestations than during heavy ones. This is primarily a problem of individual interest and participation, and the success of any insect control campaign is the result of the activity of each farmer involved.

The last session of the Legislature provided that the handling of bee inspection problems be a part of the responsibilities of this office. This work was organized and equipped during the spring of 1941. Mr. J. F. Reinhardt of the University of Minnesota was employed as the State Apiarist, and his time has been fully occupied with this work. After a cessation of bee inspection work for several years it was necessary to start almost from scratch, and the large amount of work which has been accomplished during the past two seasons is gratifying. The success and value of this activity will become more apparent as time goes on. The first summary of Mr. Reinhardt's work is included in this report.

MAJOR INSECT CONTROL PROBLEMS

GRASSHOPPER CONTROL, 1941-42

O. B. Hitchcock, Assistant State Entomologist

The migration of the lesser migratory locust *(Melanoplus mexicanus)* has been of great importance and interest since the extremely heavy infestation of July, 1938. As reported in the Twenty-seventh and Twenty-eighth Reports of the State Entomologist[1] the movements of these insects for 1938, 1939, and 1940 were as follows: the flights which originated in North and South Dakota first entered eastern Montana on July 1, 1938, and migration continued during much of the summer. The egg bed for 1939, laid down by the migrants, covered most of the northeastern part of the State including all of Garfield, Richland, McCone, Roosevelt, and parts of Valley, Daniels, Dawson, Prairie, Custer, Rosebud, Treasure, Musselshell, Petroleum, and Phillips counties (figure 1).

In 1939 the 'hoppers, after becoming adults, migrated into the north-central part of the State and a smaller area in the south-central part where they laid large numbers of eggs for the 1940 generation.

The 1940 migration was west until the 'hoppers reached the Rocky Mountains and the heaviest egg depositions in 1941 were in Cascade, Chouteau, Pondera, Teton, Toole, and Liberty counties.

[1]Mont. Exp. Sta. Bul. 336, pp. 12-16, 1939.
" " " " 384, pp. 1-5, 1941.

This area was considerably smaller than that infested during the two previous years and the intensity of infestation was not so great.

There were no recorded migrations or flights of economic importance during the 1941 season. Some small local movements were observed in Pondera, Teton, and Cascade counties and some light flights entered Judith Basin, Liberty, and Hill counties.

The only movement of *M. mexicanus* observed in the State in 1942 were small localized flights from northern Yellowstone and eastern Stillwater counties into the Yellowstone Valley and local dispersals in Big Horn County and other areas.

From 1938 to 1940 the grasshopper migration progressed mostly in a northwest and westerly direction. Each year there was a de-

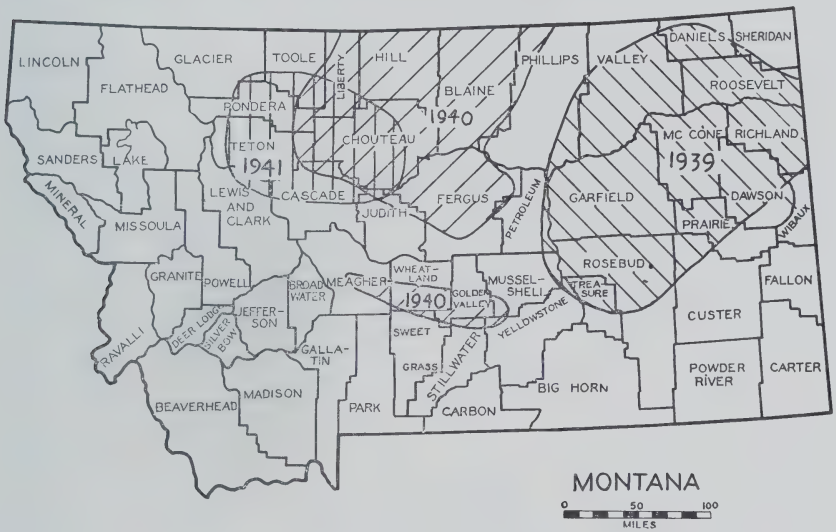


Figure 1. Grasshopper egg beds, 1939 to 1941.

crease in extent and degree of infestation until the Rocky Mountains were reached in 1940. Since that time no comparable migrations have been observed.

It has been interesting to note, especially since 1939, that there has been a marked decrease in intensity of 'hopper populations, apparently due to unfavorable weather conditions, other natural factors, and intensified control work. Regardless of these adverse factors the numbers of 'hoppers present each year have been great enough to be a serious threat to crops. It seems that the tremendous populations that were present in 1938 and 1939 have made it possible for the 'hoppers to maintain a threatening condition due largely to sheer weight in numbers.

Grasshopper adult and egg surveys made in the fall of 1940 indicated that outbreaks were likely to occur in the south-central and northern half of the State, east of the Divide, with the most severe areas being in Sheridan, Daniels, Roosevelt, Valley, Phillips, Blaine, Hill, Toole, Pondera, Teton, Cascade, Wheatland, Musselshell, Yellowstone, Treasure, and Rosebud counties.

The first reports of eggs hatching were received on May 8 but the general hatch in the south and central part of the State did not occur until May 15. In the northeastern counties no large hatches were observed until May 24.

TABLE 1. CROP LOSSES FROM GRASSHOPPERS AND SAVINGS FROM CONTROL WORK IN DOLLARS

	1941		1942	
County	Loss	Savings	Loss	Savings
Beaverhead	1,200	5,000	—	—
Big Horn	5,650	51,900	416,750	285,425
Carbon	—	—	31,310	22,800
Cascade	165,850	69,350	21,700	29,800
Chouteau	64,000	125,000	5,300	9,500
Custer–Powder River	—	—	—	3,175
Daniels	900	200	—	—
Dawson	3,500	650	75,500	5,700
Fergus	200	500	—	—
Flathead	33	44	—	—
Garfield	10,350	2,950	67,750	250
Glacier	21,050	7,320	6,150	8,950
Golden Valley–Musselshell	127,350	239,500	226,000	76,000
Hill	25,000	177,500	—	—
Judith Basin	85,200	2,900	23,300	—
Lake	1,800	2,450	—	—
Lewis and Clark	3,434	300	—	—
Liberty	6,250	18,000	—	—
McCone	—	—	108,000	75,350
Meagher	2,450	—	—	—
Petroleum	9,500	1,850	—	—
Phillips	—	250	—	—
Pondera	495,825	2,515,700	8,700	25,450
Powell	8,250	1,585	—	—
Prairie	9,950	3,500	107,000	6,500
Richland	800	300	22,100	50
Roosevelt	9,600	10,000	—	—
Rosebud	3,250	395	65,200	22,600
Sanders	8,700	24,000	—	—
Stillwater	16,600	2,750	67,500	18,005
Sweet Grass	2,000	10,000	7,350	8,700
Teton	214,200	614,700	76,000	61,000
Toole	18,700	63,850	1,950	4,350
Valley	16,200	23,165	6,500	1,275
Wheatland	2,500	1,000	—	—
Yellowstone	26,500	254,800	256,635	155,441
TOTAL	1,420,292	4,231,409	1,599,695	817,671

A three-week period of cool, damp weather during May and June over much of the State caused the hatch to be uneven and somewhat delayed, especially in Sheridan, Daniels, Roosevelt, Valley, Phillips, Blaine and Hill counties. It is thought that these weather conditions may have caused many young 'hoppers to die and may have damaged some eggs so that they did not hatch. It is quite evident that some natural control took place because the infestation in this area was not nearly so severe as indicated by the survey.

Pondera was by far the most severely infested county in the State. The estimated crop savings realized from the control program was over 2½ million dollars compared with slightly less than ½ million dollars damage. Seven hundred sixty-four farmers spread 1441 tons of mixed bait over 177,500 acres of land in the county.

Other counties which had heavy infestations of grasshoppers and put out large quantities of bait were Teton, Toole, Chouteau, Cascade, Hill, and Yellowstone (see table 1).

The control program over the State was, in most cases, quite successful. The estimated savings as a result of the work done was nearly 4½ million dollars compared with less than 1½ million dollars' damage. Three thousand three hundred twenty-five farmers spread 3,668 tons of bait over 671,420 acres of land. The total county expense in putting on the program was $20,007—the farmers contributed $50,978, and the Federal Government spent $108,525 for 'hopper control in the State, making a total cost of $179,511.

The dominant species in most parts of the State was *Melanoplus mexicanus* with *M. bivittatus* ranking second in importance. In the north-central part of the State *M. packardi* was second to *M. mexicanus* as the dominant species. It also occurred in large numbers in Stillwater County. Heavy populations of *M. differentialis* were found in small areas in Wheatland, Prairie, and Big Horn counties. In spots in Yellowstone and Big Horn counties *M. femur-rubrum* was observed in large numbers. Heavy concentrations of *Disosteira carolina* were found in Golden Valley County.

The vegetation along the margin of fields and on idle and abandoned land was quite heavy and remained green most of the summer. Because of the abundance of feed there was little migration of grasshoppers into crop land until almost time for harvest so that little damage was done to winter wheat.

In the eastern part of the State large numbers of *M. bivittatus* and *M. differentialis* were recorded dying from what appeared be a fungus or bacterial disease. It was observed that blister beetle larvae had destroyed many 'hopper egg pods in the south-central counties. No other reports of parasites or predators reducing grasshopper populations were received.

A period of continued cool, wet weather during much of August, September, and October was unfavorable for grasshopper

egg deposition. There is little doubt that these conditions were important in reducing the 'hopper problem the following year.

The grasshopper situation in 1942 was less severe over most of the State than it has been for the last five years. This was due largely to a smaller number of eggs in the soil, and to the

TABLE 2. SUMMARY OF BAIT USAGE

	1941			1942		
County	Tons bait dry wt.	No. farmers using bait	Acres baited	Tons bait dry wt.	No. farmers using bait	Acres baited
Beaverhead	1.4	5	250	——	——	——
Big Horn	75.0	149	14,800	184.0	100	34,000
Broadwater	.25	2	50	——	——	——
Carbon	——	——	——	13.0	30	2,933
Cascade	173.0	445	27,500	27.3	72	11,600
Chouteau	308.0	190	37,000	5.2	50	1,200
Custer-Powder River	——	——	——	5.9	21	1,368
Daniels	1.0	2	100	——	——	——
Dawson	4.0	8	325	4.25	17	820
Fergus	5.0	32	270	——	——	——
Flathead	.5	5	60	——	——	——
Gallatin	1.3	5	250	——	——	——
Garfield	2.0	3	340	5.5	30	1,200
Glacier	.75	5	130	——	7	520
Golden Valley–Musselshell	10.0	94	2,000	13.1	532	2,500
Hill	143.0	125	40,000	——	——	——
Judith Basin	12.0	49	1,940	——	4	10
Lake	13.25	12	1,400	——	——	——
Lewis and Clark	1.0	6	134	——	——	——
Liberty	140.0	100	20,000	——	——	——
McCone	——	——	——	107.3	46	20,840
Petroleum	2.0	8	266	——	——	——
Phillips	1.0	5	80	——	——	——
Pondera	1,441.8	764	177,500	5.55	17	2,740
Powell	1.24	9	119	——	——	——
Prairie	2.0	8	730	22.5	33	3,110
Richland	2.0	15	10	——	10	5
Roosevelt	4.0	28	10,765	——	——	——
Rosebud	3.5	20	17	3.0	75	1,733
Sanders	56.0	35	7,200	——	——	——
Stillwater	10.0	16	2,650	8.7	42	3,540
Sweet Grass	1.4	8	285	4.0	11	500
Teton	539.0	525	130,300	28.7	48	3,600
Toole	385.0	175	45,000	7.0	10	1,654
Treasure	45.0	25	8,500	——	——	——
Valley	84.0	34	10,499	4.5	6	375
Wheatland	6.0	13	500	——	——	——
Yellowstone	193.0	400	95,200	242.1	429	62,600
TOTAL	3,668.39	3,325	636,170	691.60	1,590	157,773

fact that cool, wet weather during the spring months delayed the hatch and development of the 'hoppers to such a degree that their presence was not especially apparent until most crops were harvested or so far advanced that the damage to them was not noticed. As a result of this and the extreme shortage of labor comparatively little control work was carried on.

A comparison of the 1941 program with 1942 in table 3 indicates that as the grasshopper menace deceases there is a tendency for farmers to neglect control work. In 1941 there were nearly twice as many counties participating in the control program, over twice as many farmers taking part and over five times as much bait used as there was in 1942. The lack of interest and cooperation in years of light infestations often causes them to be more costly than years of heavy populations as is shown in table 3. In 1941, a year of comparatively heavy infestation, the estimated damage caused by 'hoppers was approximately $179,000 less than the estimated damage in 1942, and the estimated savings from control work in 1941 nearly 3½ million dollars more. Besides the losses

TABLE 3. SUMMARY OF GRASSHOPPER CONTROL PROGRAM

	1941	1942
No. Mixing Stations	32	23
Counties actively engaged	32	19
Farmers using bait	3325	1590
Dry bait used	3668.39	691.6
Acres baited	671,420	157,773
Estimated loss	$1,420,292.	$1,599,695.
Estimated savings	$4,231,409.	$817,671.

sustained in years of lighter infestations the populations are allowed to build up for more serious situations in following years. If the light and incipient infestations were controlled greater savings would be made with relatively small cost.

The areas in the State which were most heavily infested with grasshoppers were northwestern Yellowstone, southern Musselshell, southeastern Golden Valley, and northeastern Stillwater counties in the vicinity of Broadview, Acton, and Rapelje; northeastern Rosebud, southeastern Garfield, southwestern Prairie, and northwestern Custer in the vicinity of Rock Springs and Crow Creek; and southern McCone County. The Camas Prairie and Lonepine areas in Sanders County and most of Big Horn County were also heavily infested.

Cool, wet weather during most of May and June caused the hatch over most of the State to be quite late and uneven. The first general hatch occurred about June 15. Nymphal development was also delayed by the unfavorable weather conditions.

The dominant species over the State was *M. mexicanus*, with *M. bivittatus* second in importance. Other species were not ob-

served in numbers large enough to cause any great amount of injury.

It is estimated that cool, wet weather during the spring months reduced the grasshopper populations from 5 to 25 per cent. The heaviest mortality was in the northeastern and northern parts of the State. In the Gibson area of Sweet Grass County approximately 30 per cent of the *M. bivittatus* adults were killed by fungus. Other areas where fungus or disease killed large numbers of 'hoppers were in Fallon, Valley, Custer, Roosevelt, Pondera, Cascade, and Teton counties.

Sarcophagid flies were numerous over must of the State but indications are that they did not parasitize a high per cent of the 'hoppers. In Roosevelt and McCone counties large numbers of grasshopper egg pods were found parasitized by beefly and blister beetle larvae.

GRASSHOPPER OUTLOOK FOR 1943

The 1942 grasshopper egg survey indicates that the 1943 infestation in most parts of the State will be spotted and not so severe as in the past five years. The most severely infested area will probably be in Big Horn, Yellowstone, Stillwater, Golden Valley, and Musselshell counties. Other counties which may have smaller local areas with heavy 'hopper populations are Dawson, Fergus, Judith Basin, Teton, and Toole. In addition to the above it may be necessary to carry on control work in Pondera, Cascade, Chouteau, Lewis and Clark, Wheatland, Sweet Grass, Sanders, Carbon, Treasure, Rosebud, Garfield, Prairie, Custer, Fallon, Wibaux, McCone, Richland, Roosevelt, Valley, and Phillips counties.

In addition to controlling severe infestations and preventing heavy crop losses, the aim of the coming grasshopper campaign should be to control all small incipient outbreaks to prevent serious infestations from developing during the present period of emergency.

The following are some of the unusual problems which will face those involved in control campaigns in 1943. The acute labor shortage will add to the difficulties of some counties in obtaining workers for the mixing stations, in baiting large areas, and in practicing proper cultural control methods. There will no doubt be an increase of idle and abandoned land. There may be a shortage of control materials and of transportation to the areas needing them. Equipment for mixing and spreading bait will not be readily available.

These problems make the situation serious especially at a time when the production of food is so essential. All interested parties

should recognize these problems and help to reduce their importance as far as it is humanly possible to do so.

MORMON CRICKET CONTROL, 1941-42

O. B. Hitchcock, Assistant State Entomologist

During the last two years the Mormon cricket infestation throughout the State has decreased to such an extent that it is no longer the major insect problem that it was.

In 1941 there were five counties with cricket populations high enough to make control measures necessary. These infestations were in Beaverhead County west of Monida near the Montana-Idaho line; Big Horn County east of Lodge Grass and Owl Creek and Sioux Pass, and southwest of Hardin in the vicinity of Beauvais Creek; near Pryor; Chouteau County in a large area including Highwood, Geraldine, Square Butte, and Montague; Sanders County in Fairy Basin, McDonald Basin and in the hills east of Camas Prairie; and in Yellowstone County along Pryor Creek, Hay Creek, Blue Creek, Fly Creek and surrounding area.

The infested areas in Beaverhead and Sanders counties were relatively small and after the control work was completed only a few scattered crickets could be found, with exception of the high areas in Beaverhead County, where heavy populations occurred. The populations in other infested areas were not so heavy as in previous years but were quite extensive and control work was done on a crop-protection basis. Because of the control program very little crop damage occurred.

Until 1939 the use of bait was not recommended as an effective method of controlling Mormon crickets; however, the use of sodium fluosilicate as the active agent instead of sodium arsenite was proved successful, and since 1939 the amount of bait used has increased steadily until this year when its use almost entirely replaced the use of sodium arsenite dust. The bait has many advantages over the dust in that it is more effective, easier and less dangerous to handle, cheaper, and the hazard of livestock poisoning is greatly decreased. The first hatching of Mormon cricket eggs in 1941 was reported in Big Horn County on March 31. The main hatch over the State, however, did not occur until about the 15th of April.

In Yellowstone County a few eggs were found to be parasitized by *Sparaison pilosum* Ashm. The predatory wasp *Palomedes laeviventris* Cress. was observed in most of the infested areas but was not numerous enough to be important in reducing the population of Mormon crickets.

No extensive migrations were observed. However, there was some movement of small bands of crickets out of the Wolf Moun-

tains into crops in the Owl Creek and Sioux Pass areas in Big Horn County.

In 1942 it was necessary to carry on Mormon cricket control work in only two counties in the State. These infestations were located on Owl Creek and Sioux Pass east of Lodge Grass, on Beauvais Creek in Big Horn County and in the southeastern corner of Yellowstone County east of Pryor Creek.

To prevent reinfestation of the lower lands it was thought that a control program would be needed in Beaverhead County west of Monida, in the vicinity of Beaver, Big Beaver, and Poison creeks, near the Montana-Idaho State line. The 1941 campaign was successful to the extent that the only crickets left in this area were on the Continental Divide at about 7,800 feet elevation. In the fall of 1941 this area was visited and large numbers of crickets were observed. Again in the early summer of 1942 the area was scouted and only an occasional cricket could be found so that control work was not necessary. Since it seemed unusual that there were no crickets where such large numbers of adults had been found the previous fall, another investigation was made in September of 1942. It was found that there are large numbers of eggs in the ground and that this is apparently a "hold-over" area where the eggs hatch in two years.

TABLE 4. SUMMARY OF MORMON CRICKET CONTROL, 1941 and 1942

	1941	1942
Crop savings	$87,290	$38,750
Crop losses	$2,680	$1,200
Crop acres protected	46,160	22,038
Acres injured	4,635	890
Crop acres infested	172,800	14,196
Range acres infested	1,007,340	569,758
Total infested	1,180,140	583,954
Acres dusted	3,757	912
Acres baited	24,419	6,873
Pounds mixed dust	17,396	5,945
Pounds mixed bait (dry weight)	197,043	110,706

In 1939 the first discovery of the hold-over phenomenon was made in the Big Horn Mountains in Wyoming. At this time it was found that Mormon cricket eggs laid at high altitudes often require two years to hatch. Ordinarily Mormon cricket eggs laid in the summer or fall hatch the next spring. In a "hold-over" area, however, they remain in the ground for two winters and a summer before hatching.

From the eggs that were collected in Beaverhead County in the fall of 1942 it was found that 60 per cent were viable and contained well developed embryos, 10 per cent were not viable, and 30 per cent had been parasitized by *Sparaison pilosum*.

On investigation of the eggs it was also found that parasites

which emerged from eggs that were attacked in the fall of 1941, were apparently able to successfully parasitize eggs that had escaped the year before. This gave *S. pilosum* two chances at the same set of eggs. Regardless of this high degree of parasitism there appear to be enough viable eggs left to cause a serious infestation for 1943.

The first hatching of Mormon cricket eggs was observed in Big Horn County during the first week of April. The hatch was irregular and continued over several weeks due to the long period of cool, wet weather which prevailed over most of the State during April and May. Adult crickets were observed about the middle of June and egg deposition began early in July.

Except in the Beaverhead area the egg parasite, *S. pilosum*, did not occur in large enough numbers to greatly reduce the infestation. The predatory wasp Palmodes was not observed in sufficient numbers to be of importance in reducing the number of crickets. In Big Horn and Yellowstone counties crows, hawks, blackbirds, and magpies were observed feeding on crickets. Relatively few migrations were observed during the season. In most cases the crickets remained in the general area where hatching occurred.

Indications are that little control work will be necessary in 1943. Possibly a small amount of baiting will be needed again in Yellowstone and Big Horn counties. The Beaverhead County infestation should be watched carefully to prevent reinfestation of the lower lands. The Mormon cricket population in northern Glacier County seems to be increasing and some work may be necessary there.

STORED GRAIN INSECTS

Figure 2. Granary weevil, greatly enlarged.

Two surveys of the State have been made, one in 1941, and the other in 1942, to obtain information on the species of grain pests present in the State, their distribution, and the factors affecting their abundance. These pests are much more widely distributed and much more common in grain storage than was suspected. They are a real problem under certain conditions, and may at times become limiting factors in the marketing of stored materials of this sort. Harvesting during both the 1941 and 1942 seasons was carried out under difficult conditions and in both years a great deal of grain went into the granaries with a greater moisture content

than desirable. As the amount of grain going into storage and as the length of time it is kept in storage increases, we can expect continued increase in the importance of stored grain pests of all kinds.

The more common of these pests are discussed in the Twenty-eighth Report of the State Entomologist, Montana Agricultural Experiment Station Bulletin 384 on pages 12 to 16. Single sheet leaflets dealing with these insects are also available from the Montana Extension Service, and may be obtained by asking for Circular Series A—18, 21, 24, 32 and 43.

Figure 3. Sawtooth grain beetle. Greatly enlarged.

OTHER IMPORTANT INSECT PESTS, 1941-42

NEW INTRODUCED LIVESTOCK PESTS

PRIMARY SCREW WORM.— The adult primary screw worm *(Cochliomyia americana* C. and P.*)* is a bluish-green fly with a striped thorax. It is a little larger than a housefly, and when at rest the wings are held a little more directly over the back than in the house fly or the larger blue bottle flies.

Montana is far out of the normal range of this pest, and its appearance in this State in the summer of 1941 came as a surprise. Apparently it gained entrance to Montana in the early spring of that year through the introduction of cattle imported from Mexico. No reports of this pest were received during 1942, and it is most unlikely that it would be able to stand the rigors of the winter in this latitude. Trouble, then, would be expected only from southern cattle brought into the State and from native cattle running with or near them, and this difficulty would end with the advent of winter. Some loss was experienced throughout the summer of 1941, and possibly it may be years before it again appears in our region.

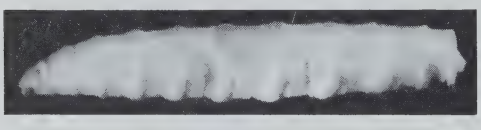


Figure 4. Primary screw worm taken from a calf near Custer, Montana. Enlarged.

The adult females lay their eggs in the wounds of many domesticated animals, injuries such as those caused by barbed wire,

tick feeding, needle grass, dehorning, castration, branding, etc., and they may also attack the navel of newborn calves. Humans are occasionally attacked and there are a number of records of nose or ear infestations in man.

These flies have a great ability to reproduce. A female may lay approximately 3,000 eggs in batches of from 10 to 400. Three hundred may be laid in from four to six minutes. The eggs hatch in less than a day under usual conditions, and the larvae complete their growth in from three and one-half to four and one-half days. Fully developed larvae (figure 4) drop to the ground where the transformation to the adult takes place. Under the best of conditions a complete generation may develop in about 11 days. It is, then, possible for many generations to appear even under Montana conditions, and for very heavy infestations to occur in the host animals.

The primary screw worm is found throughout the southern states and far into South America. The 1941 Montana records were from Yellowstone and Treasure counties where in August the maggots were taken from the navel of a three weeks-old calf. According to information received from the rancher another calf had a severe infestation in a fresh brand and seven out of eight castrated calves in one group became infested. The area involved Meyers, Custer, and Big Horn, and included stock belonging to thirteen different ranchers. Forty-four animals were known to have been attacked and several of the ranchers merely listed their stock as being infested, with no numbers of animals given. Cattle, horses, pigs, and dogs suffered injury.

While this is the first record of the primary screw worm in the State it is entirely possible that this pest has been brought into Montana at other times. As has been previously pointed out, the chances are that it cannot survive the winter here, and our problem is one of continuous introduction. Most of the cases in 1941 occurred from the last of July to September 15th, indicating that it took some time for the infestation to develop to a size which was readily noticeable, for the suspected introduction of the maggots dated back to April 18, with the arrival of the Mexican cattle.

It is important that future shipments of southern cattle into Montana should be thoroughly examined for wounds which might possibly be infested with this insect. Any maggots which may be recovered from such situations should be sent, preferably alive, to the Department of Zoology and Entomology, Montana Agricultural Experiment Station, Bozeman.

SPINOSE EAR TICK.– This tick *(Otiobius megnini* Duges) is primarily a southern pest. In the United States it is most common in the southwest, but it has been reported from as far north as Iowa, Alberta, and Oregon. Concerning these ticks in Canada, Hearle says that they "probably were introduced on imported animals and fortunately they do not appear to have become established."

South of the United States the species is known from Mexico, Central and South America, as well as other parts of the world.

The first Montana record of the spinose ear tick was based on specimens collected near Park City in February, 1916, under conditions which indicated that it had been present for several years. This was reported in the Fourteenth Report of the State Entomologist, Montana Agricultural Experiment Station Bulletin 112, page 67 (1916). As many as 109 ticks were taken from the ears of one calf at that time. Apparently the infestation disappeared, for this pest was not again reported until the spring of 1941, when specimens were submitted by Dr. W. J. Butler, State Veterinarian, which were collected from the ears of Mexican cattle that had been shipped into the upper Yellowstone Valley. Since then several lots of specimens have been examined.

The spinose ear tick is known to attack cattle, horses, sheep, cats, and occasionally man. Its life history, as it is known, is as follows: the newly-hatched, tiny, six-legged seed ticks enter the ears of the animals attacked and attach themselves well below the hair line. In a week or two they become engorged and shed their skins, becoming eight-legged nymphs which bear little resemblance to the first stage. These nymphs are covered with small spines, and are constricted somewhat across the middle (see cover illustration). Ticks in this stage remain in the ears for from one to seven months when they drop to the ground, crawl into dry, protected places, and shed their skins a second time. This moult produces the adults. which are spineless and somewhat flattened. It is not believed that the adults attach to any animal or take food of any kind. Mating and egg laying then take place and under favorable conditions the eggs may hatch in 10 days. Soon after, the little ticks are ready to attach to any of their hosts, settle down in the ears, and continue the life cycle. They may live for three months if no host is found.

The factors which limit the spread or continued development of this pest are unknown, but judging from previous experience, and in spite of the lack of specimens received in 1942, it might remain for some time before it disappears.

A few ticks in the ears of an animal probably do little damage. However, when gross infestations exist considerable injury may occur. The ticks and ear secretions may completely plug the opening and some of them may move as far in as the ear drum. The infested animal usually shakes its head and moves it from side to side. There is a tendency to rub or scratch the ears when the irritation is intense, and young animals often run as if attempting to relieve the nervous tension. Infested animals do not do well. Some of them lose flesh and, rarely, the calves may die.

Because of the point of attachment of the ticks, ordinary dipping will not remove them. A mixture of 2 parts of pine tar to

1 part of cottonseed oil injected at the rate of about ½ ounce per ear, with a warm syringe, is recommended by Imes This mixture kills the parasites present and protects against reinfestation for about a month. In cases where an infestation is suspected, the animals should be examined, and if no ticks are visible the ear should be probed with a piece of bailing wire. A loop should be formed in the end of the wire to prevent injury to the ear.

Montana records are all from the southeastern part of the State, Park City, Biddle, Custer, and Mission.

MISCELLANEOUS RECORDS AND OBSERVATIONS

SAY'S STINKBUG.— This large, green stink bug, *(Chlorochroa sayi* Stal*)* has been locally abundant in the State for the last ten years, and has caused considerable local and sporadic damage to wheat. In 1940 it was seen in numbers as far east as the North Dakota line, but in 1941 and 1942 it was conspicuously rare over much of the previously infested territory. During the past year but one specimen was seen on the study plots at the North Montana Branch Station near Havre.

In June, 1941, some terminal growth of potato vines in Yellowstone County suffered from the attack of Say's stinkbugs. As many as ten specimens per plant were noted. No similar infestations were found in the same area during 1942.

CORN LEAF APHID.— During the late summer of 1941 the corn leaf aphid (*Aphis maidis* Fitch) was sent in from Glasgow and Hardin, and was seen in other areas in the eastern part of the State. In the infested fields this bluish-green plant louse was very abundant on leaves, causing considerable curling. Apparently it was not a problem during the 1942 season.

This pest attacks corn, millet, broom corn, sorghum, and Sudan grass. In the southern part of the United States it winters on barley, but it is not known where the winter is spent in our area, nor has its life history been worked out completely. It is usually not an important pest, and adequate control measures are not known.

THE POTATO AND TOMATO PSYLLID.— The 1941 adult populations of this pest (*Paratrioza cockerelli* Sulc.) were alarmingly high in early potatoes until checked by very high temperatures from July 16-19. Slight reductions in yield resulted in some areas. Growers have gradually become less 'psyllid-conscious' since the outbreak of 1938 and reduced yields are commonly attributed to other causes.

Early season populations of psyllids were low in 1942. In the Yellowstone Valley potato fields planted during April and the first half of May showed symptoms of psyllid yellows by early July, and some reductions in yield resulted. A general outbreak was apparently checked by high temperatures in July, when half the

days showed temperature maxima above 90° F. Fields planted after June 1 remained rather uniformly free from psyllids and the psyllid yellows disease.

Vines infected by psyllid yellows were seen in potato plantings in Jefferson, Gallatin, Carbon, and Big Horn counties, in addition to the Yellowstone Valley plantings from Laurel to Glendive.

RED HUMPED APPLE CATERPILLAR.—During the past few years requests for information on the control of the red humped apple caterpillar (*Schizura concinna* S. and A.) have been received in increasing numbers. Although these caterpillars are striking and conspicuous, they are of but minor importance and only locally are of sufficient abundance to warrant control measures.

When fully developed, the larvae have a reddish-yellow appearance due to the alternating stripes of these colors on the body. These stripes are more conspicuous on the sides. Slender, dark, pointed processes occur along the back, and are most conspicuous on the segments just behind the head. One of the segments toward the head is enlarged and red, and from this structure the insect gets its common name. When irritated the rear end of the body is raised considerably above the surface upon which the larvae is standing. Because they are voracious eaters, feeding openly on leaf tissue, they can be controlled without difficulty by the usual lead arsenate sprays.

All of our Montana records are from the western third of the State, Big Fork, Deer Lodge, Dixon, Heron, Kalispell, Ronan, and Troy, and all observations were for the month of August but one, in September.

DIAMOND BACK MOTH.— The larva of this little moth (*Plutella maculipennis* (Curt.) attacks cabbages, mustard, and related plants. While it is widespread in Montana, its attack on garden crops is usually so slight as to be hardly noticeable, and only occasionally does it become so abundant as to require control.

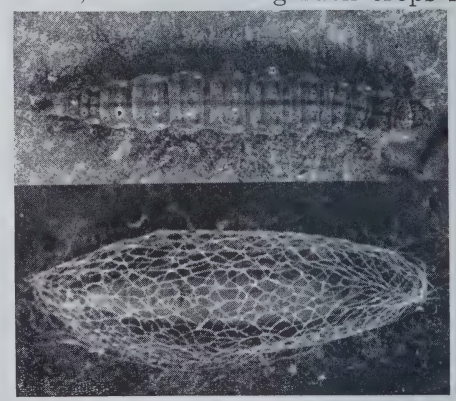


Figure 5. Diamond-back moth, larva above, cocoon below. Greatly enlarged.

Recently, however, it became abundant in large plantings of commercial mustard in the north-central part of the State, and during the summer of 1941 it damaged acreages of this crop by boring into the pods and destroying the seeds. It was very abundant that season also on several species of wild mustard, notably tumbling mustard (*Sisymbrium altissimum*).

SUGAR BEET WEBWORM.— The occurrence of this insect (*Loxostege sticticalis* (L.)) was quite general throughout the State in 1941. Heavy infestations were reported from localized districts which were fairly well distributed throughout the sugar beet growing areas. Control measures were necessary in these areas. In Yellowstone and Carbon counties practically the entire sugar beet area was sprayed at least once. The damage was limited almost entirely to defoliation of the plants, the infestation not being severe enough to injure the crown. Heavy infestations were recorded in flax fields. Their feeding activities were confined to stripping of the leaves so it was difficult to estimate the damage. This appears to be the first time that this insect has been reported in large numbers in flax in Montana. The severity of the infestation in a flax field in Pondera County was judged from the fact that 50 to 70 pupal cases could be obtained from sifting a square foot of soil in the field.

A heavy flight of second generation moths appeared but over 90 per cent of these proved to be sterile.

A moderate to heavy flight of moths was observed during June of 1942. Owing to the high incidence of sterility among them, very few eggs were laid. Some spraying was done in Yellowstone, Carbon, and Big Horn counties. The infestation was very light and no damage was reported. Some second generation moths appeared in the northern part of the State but all of these were sterile.

SPRUCE BUDWORM.— An outbreak of the spruce budworm (*Archips fumiferana* (Clem.)) occurred on the Gallatin Forest during the summer of 1942. It was noted in large numbers on the east slope of the Bridger Range, and considerable damage was done to douglas fir (*Pseudotsuga taxifolia*), engleman spruce (*Picea engelmanni*), and alpine fir (*Abies lasiocarpa*). A trip was made into the area in the company of Mr. A. H. Abbott, Forest Supervisor, on July 10th, at which time the larvae were abundant. On August 9 no larvae were found in the same area but injury to douglas fir, especially to some of the young trees, was very evident.

The larvae collected in July were moderately heavily parasitized. Two species of parasites were reared from this collection, *Glypta fumiferana* Vier., and a species of Microgaster which is apparently undescribed according to Mr. C. F. W. Muesebeck, to whom the specimens were transmitted for determination.

ARMY CUTWORM.— During the spring of 1942 parts of the State experienced the worst infestation of the army cutworm (*Chorizagrotis auxiliaris* Grote) in several years. A large area in eastern Montana was involved, and there was considerable local crop injury. Some grasshopper bait was spread in the control of these pests.

PALE WESTERN CUTWORM. — This pest (*Agrotis othogonia* Morr.) has been extremely injurious in the State in years past.

During 1941 and 1942, however, no reports were received and no damage was seen. The moist spring of 1942 would indicate that it is not likely to be a problem during the 1943 growing season.

CORN EARWORM.— The heaviest infestation of sweet corn by the corn earworm (*Heliothis armigera* (Hbn.)) in many years was experienced during the spring of 1941. Although it was general throughout the State, the greatest damage was done in the Bitterroot Valley where many early plantings were a complete loss. Appearance of adults and egg laying occurred before the silks appeared and by the time they were well out the larvae were found in the tips of the ears. The abundance of adults early, together with the mild winter preceeding, indicate a possibility of overwintering in this region. In 1942 there were fewer of these pests than usual over much of the State and no great abundance was reported anywhere in Montana. Control is discussed in Montana Extension Circular Series A—11.

RASPBERRY ROOT OR CROWN BORER. — Raspberry plants which appear to be stunted and with little vigor, or on which the lateral spring growth wilts suddenly causing the death of the cane, should be examined for the attack of the raspberry root or crown borer (*Bembecia marginata* Harris). This injury is most apparent in old plantings and in some parts of the country is said to be a rather important pest. The only specimens in the Montana Agricultural Experiment Station collection were taken in Bozeman in August of 1938 and 1942, although reports of the occurrence of borers in raspberries on the east shore of Flathead Lake have been received.

The adult of this species is a slender, wasp-like, clear winged moth. It is rather sluggish, and may be found sitting on the leaves of raspberries or flying about the plantings late in the summer. It lays its eggs on the leaves and canes, and the larvae which hatch from these eggs bore into the canes close to the crown. They feed on the canes in the fall and pass the winter in this situation. In the spring they work their way down into the crown where they feed and pass the second winter. The larvae at this time are yellowish-white, fleshy, with the body segments showing up strongly because of the narrow constrictions between them. Pupation occurs the following spring and the new adults appear about the first of August. It thus takes two years for a generation to develop.

Besides raspberries, loganberries and occasionally blackberries are known to be attacked. Canes which are not vigorous or which shown signs of rapid wilting should be removed by cutting as close to the crown as possible. The application of a summer oil during the first ten days in August and at two-week intervals after that has been recommended to kill the eggs.

RASPBERRY FRUITWORM (*Byturis unicilor* Say).—At the time of raspberry picking it is not uncommon to find the core of the

berry mined and grooved by the feeding of a small, brown beetle larva. This larva may stay in or on the core or it may remain in the harvested fruit. In cases of heavy infestation it is necessary to cull a large percentage of the fruit, and the loss may be considerable. At certain times in western Montana populations of this insect may be very high and the loss of fruit in proportion. The larvae, which cause this damage, are about one-fourth of an inch long when fully grown. They hatch from minute eggs which are laid on the buds, flowers, or stems. When they have completed their development they drop to the ground, burrow into the soil, and pupate. The adults emerge from the soil early in the spring, feed on the unfolding leaves and flowers, depositing their eggs in or near the latter for the next generation. These adults are elliptical, yellowish-brown beetles, less than a quarter of an inch long.

Control involves the destruction of the adult beetles before they have had an opportunity to lay eggs, and their long period of feeding before egg laying gives time for this. In our experience, an application of a standard lead arsenate spray as the buds are forming, or a thorough dusting with a one-half per cent rotenone dust at the same time, and followed two weeks later with another application, will reduce the damage to a negligible amount.

SWEET CLOVER WEEVIL.— This European weevil (*Sitona cylindricollis* Fahr.) has proved itself to be highly destructive to sweet clover in the eastern part of the United States and Canada. Its injury seems to be greatest to new seedings, which sometimes have to be replanted, but it is not limited at all to these small plants. The obvious damage is caused by feeding on the leaves and stems and, according to observations which have been made in Ontario, this injury is primarily suffered by sweet clover although alsike and black medic are attacked. Although this pest is found on alfalfa and red clover, these two crops seem to be little injured.

Since the first observation of the sweet clover weevil in the United States in 1933, it has travelled rather rapidly toward the west. It was first discovered in this country at Middlebury, Vermont, and further surveys carried on during that season disclosed its presence in New York, Connecticut, and Massachusetts. In August and September of 1935 it was noted injuring sweet clover plantings in Ontario. It was reported from Manitoba in 1939, Illinois in 1940, Minnesota, eastern North Dakota, and eastern Saskatchewan in 1941, and on September 11, 1942, a good series of specimens was received in this office from Wibaux, Montana. Besides the above states it has been taken in Wisconsin, Missouri, and Iowa. It is probably more widely distributed in eastern Montana than the single record indicates.

From the first reports on this new pest it appears that its injury is quite severe to sweet clover. How injurious it will be in Montana remains to be seen. If it greatly damages this crop it will

be of considerable importance not only to the farmer but to the beekeeping industry as well.

The sweet clover weevil is a grayish snout beetle, from one-eighth to three-sixteenths of an inch long. It may occur in large numbers, from 25 to 100 per square yard having been reported. Injury to this crop should be watched for, and if beetles answering the above description are found they should be sent to the State Entomologist's Office at Bozeman.

Some insecticidal tests were tried in Ontario, but as yet no satisfactory method of control has been developed.

PEA WEEVIL.— During the past few years this pest (*Laria pisorum* (*Linn.*)) has increased in importance in some parts of Montana. The two areas most heavily infested at the present time include a region from the vicinity of Missoula to the north and west to the State line, and the Valley of the Clark's Fork of the Yellowstone from Bridger and Roberts north to the Yellowstone and including some areas near Billings. These areas were surveyed during the latter part of June, 1942, and although the pea weevil is widespread in them, there were but isolated spots where it was at all abundant.

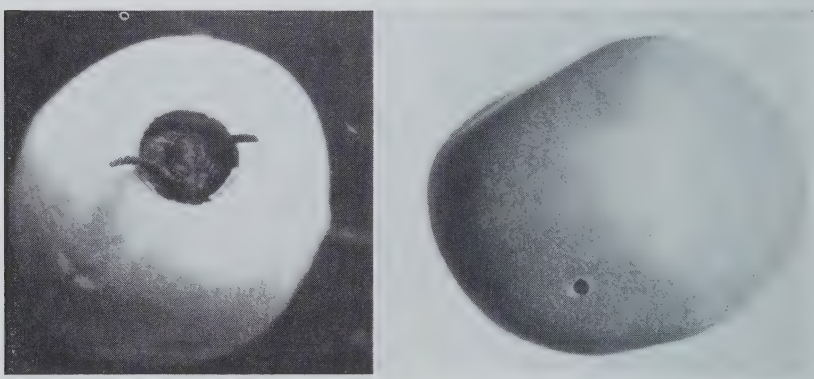


Figure 6. Pea weevil. Right, adult beetle ready to emerge from dried pea; left, injury to green pea caused by entrance of newly hatched larva. Greatly enlarged.

The apparent increase in numbers of pea weevils recently may be the result of at least two things. In the first place peas containing up to 10 per cent weevils were used for seed in some parts of the State during the spring of 1942. This certainly had an effect in the local increase of the species in areas where such seed was planted. In the second place, most of the State has experienced a series of mild winters with considerable snowfall which would allow more of the pests to live through the winter out-of-doors. The survey indicated clearly that this was taking place.

Whether the presence of this beetle in the State indicates a future of higher populations and increased difficulty, similar to other areas in the Northwest, is problematical. It has appeared in the State many times in the past and would seem to have ample opportunity to have established itself and reached maximum populations long ago. Our first records go back to March, 1912, and it has appeared periodically since then. Further, a seed company reports its presence in the Bitterroot Valley twenty-five years ago. However, this does not minimize the importance of obtaining weevil-free or adequately fumigated peas for seed, or of watching fields planted either for seed or for canning purposes, and taking adequate protective steps in case economic infestations are found.

Control of the pea weevil is discussed in Montana Extension Circular Series A-30.

BEAN WEEVIL.— The bean weevil (*Acanthoscelides obtectus* (Say)) is a beetle closely related to the pea weevil, but differing in its hosts and habits. The pea weevil will overwinter in stored peas, but will not reproduce in them. On the other hand, the bean weevil continues to breed in stored beans through the period of storage if temperatures are sufficient. While our records are doubtless incomplete, this pest seems to be much less common in Montana than the species attacking peas. We have two records, one from Bozeman, and one from Billings. It can be controlled by the usual fumigation procedures.

PLUM GOUGER.—The plum gouger (*Anthonomus scutellaris* Lec.) is the primary pest of plum fruits in the State. It apparently is present throughout the State, for it has been reported all the way from Broadus in the southeast to Polson in the northwest. It is a medium-sized weevil, bluish-brown to brown in color, with the head and thorax lighter, and with a rather conspicuous slender snout. The characteristic injury to the plums is more conspicuous than is the weevil itself. The skin is punctured, and the pulp beneath fed upon. The eggs are laid in holes somewhat similar to the feeding punctures, and upon hatching the young larvae bore directly into the pit, feeding there until they are fully grown. Pupation takes place in the pit and the adults emerge in late August or in September. They feed very little that season, and soon find sheltered quarters for winter hibernation. In the spring they emerge and feed on the buds and leaves.

To control these pests the trees should be sprayed with the usual lead arsenate sprays before the blooms have opened, and at ten-day intervals until the fruit is well developed.

PLUM CURCULIO.— In the First and Second Reports of the State Entomoligist, Cooley reported that the plum curculio (*Conotrachelus nenuphar* Herbst) was possibly present in the Bitterroot Valley in western Montana. In 1922 apples at Hamilton bore typical scar injury of this pest. Not until June 1942, though, were specimens

actually taken in Montana, when a mixed collection of this species and the plum gouger was received from Miles City.

The plum curculio is a "broad-shouldered" snout beetle about a sixth of an inch long, brown or black in color with lighter markings and with rough-looking wing covers. It is primarily a pest of stone fruits, but may cause considerable injury to apples. Feeding punctures are quite similar to those of the plum gouger. The egg punctures are characteristic of the species. After the egg has been placed beneath the skin, the female turns around and makes a crescent-shaped slit partially around and beneath the egg cavity. This type of wound is not made by the plum gouger and will serve to indicate whether or not the plum curculio is present.

The larvae burrow into the fruit and lie next to the pit, and the fruit often drops prematurely. Pupation is in the soil and in about a month the new generation of beetles appears above the ground. They may feed for some time in the fall, after which they hibernate in protected places.

Injury caused by this pest can be greatly reduced by spraying the trees with lead arsenate. The first application should be made just after the petals have fallen and a second, ten days later.

SEED-CORN MAGGOT.— This pest (*Hylemia cilicrura* Rond.) was especially abundant in the Yellowstone Valley during the spring of 1942, more so than in many years. The spring was very wet and cool, and the growth of crops retarded, a combination of factors which would be expected to bring on an infestation of these insects. As a usual thing this injury is limited to crops in soils rather rich in humus, but during the last spring conditions were such that bean plantings on light sandy soils showed from 10 to 30 per cent loss by the middle of June. Injury reported or observed included an area from Bozeman east and north to Froid, and seemed to center in the Yellowstone Valley near Billings, and up the Clark's Fork of the Yellowstone to a point well beyond Bridger.

Corn and peas were attacked to some extent, but by far the greatest damage was suffered by beans (figure 7). It was necessary to replant many of these fields. Usually eggs are laid in moist soil where there is plenty of decaying vegetation. The larvae may feed as scavengers on this material, but when succulent sprouting plants or large soft seeds are present they make their way into these. The larvae are typical fly maggots, cylindrical, pointed at the front end, and dirty white in color. When the infested area around Billings was visited on June 18, 1942, the adult flies were emerging from the soil in large numbers. These flies are smaller and more fragile looking than a house fly, and more grayish-brown in color.

Thorough mixing of the vegetable matter in the soil, and any cultural procedure which will tend to dry out the surface of the ground will assist in reducing the damage caused by this pest.

Figure 7. Injury to bean seedlings caused by the seed corn maggot.

MINK MAGGOTS.— On June 16, 1941, live maggots were recovered from mink pups in Helena by the Livestock Sanitary Board, and transmitted to this office for examination. On the 18th two of them were placed in moist sand. These pupated and emerged on July 1 and 2, and were identified as flesh flies belonging to the species *Wohlfahrtia meigeni* (Schin.). This and the related eastern species *(W. vigil)* not uncommonly attack living animals such as foxes, rabbits, dogs, and mink, and there are a good many records of *vigil* attacking humans, especially small children. In the case at hand the maggots were apparently the cause of the death of the mink pups.

Wohlfahrtia meigeni was first obtained for the Montana Agricultural Experiment Station when specimens were collected on May 29th, 1907, in Bozeman. Since then other specimens have been taken at Helena and Rapelje, and it probably enjoys a state-wide distribution.

CABBAGE MAGGOT (*Hylemia brassicae* (Bouche)) ON TURNIPS.— Early turnips grown in the Billings area for table use were disfigured in the spring of 1942 by larval tunnels of the cabbage maggot. Adult flies emerged June 25-30 from mature larvae and

pupae collected June 20 in soil along the turnip rows. Attack on nearby cabbage plants was noticeable, but not severe.

Damage from this maggot is most severe in cool, moist seasons. Adult flies appear in May and lay eggs in soil crevices on or near the roots of cabbages, radishes, and turnips. The larvae are destructive by riddling or disfiguring the plants below the soil surface. Young plants may be protected by soaking the soil around the roots with calomel (mercurous chloride) ¾ ounces and 1 ounce of gum arabic to 10 gallons of water. The material may be applied to the soil along the row by sprinkling can, coarse sprayer, or a cup. Ten gallons of the liquid will treat about 400-500 plants.

WHEAT STEM SAWFLY.— This broad-waisted wasp *(Cephus cinctus* Nort.*)* is a native Great Plains insect. Originally it lived on native grasses, and when large acreages of this vegetative cover were plowed up and replaced with cultivated small grains it transferred to these crops. In Montana it is most abundant and injurious in the eastern plains area north of the Missouri River, and during the last few years it has destroyed a great deal of wheat in this region.

The larva of the wheat stem sawfly weakens the wheat straw an inch or two above the ground level, and as the stems dry and the grain matures they break over and lodge. At the beginning the injury is of a marginal nature, being the worst around the edges of the field. Because of this, strip cropping, in infested areas, is likely to suffer greater injury than large, solidly blocked fields.

The life history and control of this insect can be obtained from Montana Extension Bulletin 176, or from Montana Extension Circular Series A-37.

EARWIGS.—The European earwig *(Forficula auricularia* L.*)* was first reported from the State in the last State Entomologist's Report. During the past two years two new infestations have been located. Besides previous records we now know of their occurrence in Missoula and at Bozeman Hot Springs, just west of Bozeman. The third specimen of the little earwig *Labia minor* L. to be collected in Montana was obtained in August, two miles south of Bozeman. Both of these species seem to be well established in the State at the present time.

BIENNIAL REPORT OF THE MONTANA STATE APIARIST, 1942

J. F. Reinhardt, State Apiarist

THE BEEKEEPING INDUSTRY IN MONTANA

Approximately 36,000 colonies of bees are operated in Montana. They produced about 4,600,000 pounds of honey and 150,000 pounds of beeswax for a gross income in 1942 of slightly over one-half

million dollars. A unique fact is that Montana reports the largest average crops of honey per colony in the United States, almost three times that of the national average for the past three years. This report has created some illusions about Montana beekeeping territory. However, two main factors contribute to any honey crop record, the operator and the territory, and credit for this record is due, really, to a small group of 75 professional beekeepers who own and operate 93 per cent of the bees in the State. Another avocational group of 60 operates 4.6 per cent and an amateur group, 70 per cent of the beekeepers in the State, operate 2.4 per cent of the bees.

Distribution of bees by registration group is illustrated by figure 8. These data seem to indicate that Montana's production is due to a combination of efficient commercial management plus good territory. In other states commercial management has pro-

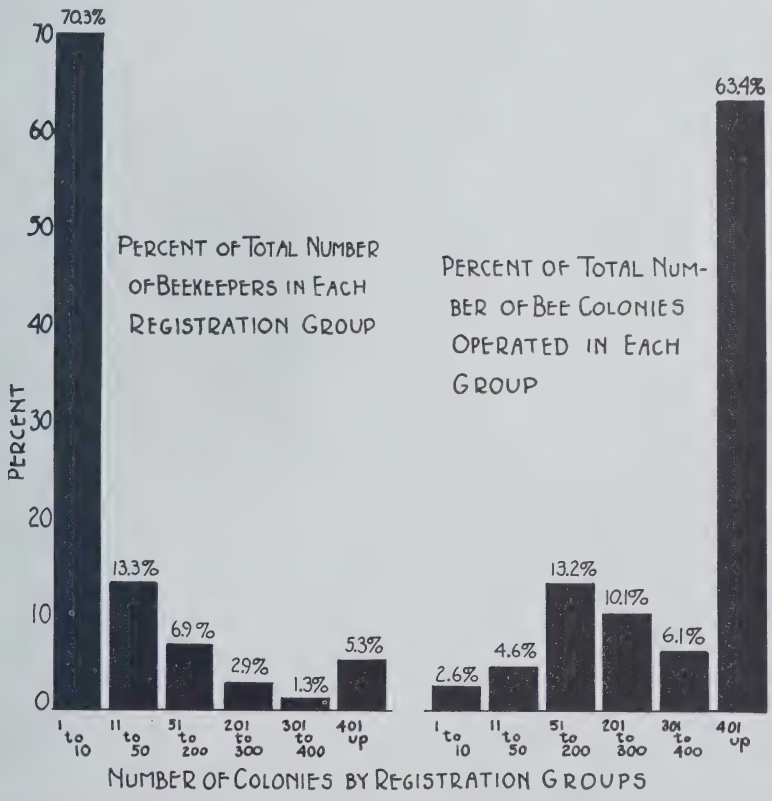


Figure 8. Distribution of bee colonies and beekeepers by registration groups.

duced better records though they are not reflected in statistics because the proportion of commercially operated bees is much smaller in those states.

DISEASE CONTROL

Paramount among the problems of all classes of beekeepers in the State is the disease, American foulbrood. Montana had no State-supported disease control program during the period 1933 to 1941. This relaxing of control permitted a marked rise in the incidence and spread of the disease. Many amateur and several professional beekeeping operations died out with the bees. Some apiaries of 40 to 50 colonies were simply abandoned with the hives left on the stands, bees dead and honey robbed out. Commercial beekeepers strove to keep territory free of disease by buying out small apiaries to burn them and salvage what was profitable. To render some inspection service of value to the State as a whole with extremely limited funds it was necessary to form an inspection policy around certain facts. The commercial beekeeper in infected territory knows American foulbrood and how to fight it in his own apiaries. He has to fight the disease to stay in business, whereas the amateur and avocational beekeeper knows little about the disease, is often indifferent, and it is not essential to his livelihood to practice disease control. Hence, the most urgent inspection appeared to be among the beekeepers of the amateur and avocational classes. Conditions further indicated the necessity of carrying out the control measures by the inspector. If control is left to individual owners only about 50 per cent of them will carry out the control, and the entire purpose of inspection is defeated. Hence, diseased bees are usually burned on the spot as promptly as possible.

It must be kept in mind that the inspection record includes mostly amateur and non-professional beekeepers, and represents conditions only among those classes. Since there is no prospect in the immediate future for the inspection of all commercial bees, the State Apiarist is impelled to exercise a policy of depending on commercial beekeepers to control disease in their own apiaries. In exceptional cases the inspection of commercial apiaries has been definitely warranted. However, in general, the profit motive is an incentive for the commercial man to clean up and salvage diseased bees as efficiently as possible.

Montana has about 500 box hives without modern movable combs (generally regarded as impossible to inspect). The State Apiarist has found it not only possible, but in numerous cases effective to inspect these hives. The procedure is simple in most cases. The hive is tipped over and the bottom pried off with a large hive tool made from an automobile spring. The combs can then be folded back and forth like leaves of a book to inspect the brood for sunken and perforated cappings. If that is not satis-

factory, a comb of emerging brood can be jerked out for more thorough examination. The comb is replaced in the slot, the bottom nailed back and the hive set up. The box hive is either dis-

TABLE 5. INCIDENCE AND DISTRIBUTION OF AMERICAN FOULBROOD IN APIARIES INSPECTED IN 1941 AND 1942

County	Colonies inspected	Colonies A. F. B.	Apiaries inspected	Apiaries infected
		1941		
Big Horn	608	286	10	9
Cascade	77	13	16	2
Flathead	47	23	16	7
Gallatin	143	24	19	7
Lake	602	211	99	33
Madison	64	0	5	0
Pondera	47	23	16	7
Ravalli	486	53	45	20
Sanders	150	27	25	6
Teton	18	0	5	0
Yellowstone	136	16	18	7
Other	150	5	4	2
Totals	2528	681	278	100
		26.9%		36%
		1942		
Blaine	288	57	10	5
Carbon	80	39	5	5
Cascade	41	22	5	2
Chouteau	2	0	1	0
Dawson	28	0	3	0
Fergus	130	30	28	6
Flathead	150	17	38	8
Gallatin	91	6	13	3
Jefferson	4	2	3	1
Lake	280	46	78	21
McCone	7	0	3	0
Park	24	0	5	0
Phillips	23	5	7	2
Pondera	71	24	15	2
Ravalli	489	69	51	15
Richland	28	0	7	0
Sanders	123	3	20	1
Stillwater	46	19	3	3
Sweet Grass	22	8	4	2
Teton	19	0	4	0
Valley	68	23	11	4
Yellowstone	329	62	29	11
Totals	2343	432	343	91
		18.4%		26.5%

eased or it is not. The inspector seldom arrives at the moment the first diseased cell appears. This method in no way excuses box hives and the human lethargy and indifference that go with them. It has simply proved expedient where it takes two minutes to inspect a hive but two hours to burn it if orders to transfer are not heeded. Needless to say the above technique is not effective on bees in wash boilers, barrels, chicken brooders, dog houses, and ice cream freezers though all are on record in the State.

In those counties where inspection is reported for both 1941 and 1942 we have a partial measure of how effective the disease control program has been. A review of the number of infected apiaries (foci of infection) indicates that in most counties the number is being reduced. Noteworthy is the case of Sanders County where in 1942 the disease was found in only three hives in one apiary. It is possible that two years' inspection will achieve complete eradication in this county. Other counties with larger areas of beekeeping territory do not show such marked reductions. Of the 608 inspections in Big Horn in 1941 all but three were in commercial apiaries. In Yellowstone County the inspection of new territory and of certain commercial apiaries together with an unfortunate outbreak of disease from one focus of infection combine to cover up what progress has been made. In Flathead, Lake, Pondera, and Ravalli counties considerable territory not previously inspected was covered in 1942, yet definite decreases in the incidence of disease and the number of foci are indicated.

The disease conditions among the 33,500 commercially operated bee colonies is another story since very few were inspected by the State Apiarist. The annual loss is estimated at 5 per cent, occurring as would be expected according to a contagious distribution. Some operators have been absolutely free of disease for years, most operators are sufficiently hampered to require several regular inspections annually and about 5 per cent loss of profits. Occasionally the incidence of disease rises to the loss of entire commercial losses have been distinctly cut down and avoided. But

In the counties where there are numerous amateur beekeepers commercial losses have been distinctly cut down and avoided. But in several other areas inspection has shown little progress in warding off these financial losses. The answer is that disease in a neighboring beehive is only one of a number of factors involved; others are the present labor shortage (making adequate inspection and disease control difficult), lack of equipment, vandalism, and most important, the failure to practice positive swarm control measures in years past. It is usually assumed the "wild" bees in trees, rimrocks, and buildings very seldom have disease. Explanations may vary, but high among them is that involving the presence of the greater wax moth which quickly destroys the combs in a dead hive. Montana has practically no wax moth. Coincident with

the absence of the wax moth, territory in Montana may be very easily infected with American foulbrood. Swarms in trees and rock ledges become infected and die out. In turn the combs are robbed, another swarm takes possession, stores a little honey and the story is repeated. How permanent these reservoirs of infection are is only a conjecture. But the adage is well illustrated that **swarm control is disease control.**

Various measures have been tried by beekeepers to avoid infection from the territory—package bees, winter locations, crop locations and bee-tree hunting. The most promising solution appears to be the use of disease-resistant bees in locations where disease is frequently picked up.

UTILIZATION OF MONTANA'S BEEKEEPING RESOURCES

The Montana apiculture laws vest the State Entomologist with an unusual authority:

> "Before a permit for the movement of bees into the State may be granted, it shall be determined by the State Entomologist that the territory to which movement is requested shall not be over-crowded and such movement shall not be detrimental to the best interests of the beekeeping industry. Beekeepers shall be notified of any request for the movement of additional bees and equipment into their established territory and shall have thirty days in which to enter any protest or reason why this permit shall not granted.
>
> "The State Entomologist may in his discretion authorize permits for the shipment of bees on combs into Montana."

This is a historic clause because, though only indirect, it grants legal authority to recognize a commercial beekeeper's ethical right to keep bees in a certain place to the exclusion of certain other commercial beekeepers. It is the beekeeper's effort to sacrifice some liberty and thereby gain some security.

Overstocking of western territory has frequently resulted in a demoralizing influence on the industry. In few businesses are the operators in more direct and complete competition with each other. When beekeepers have to compete for territory friction often develops which may lead to criminal malpractices. There are some signs of actual overstocking of territory in certain parts of the State. If Montana is the best beekeeping territory in America (as the U. S. Bureau of Agricultural Economics reports) it is only natural that Montana beekeepers are jealous of their territory. All of the beekeeping industry is located in the narrow irrigated valleys which embrace 1.5 per cent of Montana's total area, or an area approximately equivalent to the State of Delaware. Hence her beekeeping resources are not unlimited. That limit may not be known until it is exceeded.

Permission to enter bee colonies from out of State to territory now well occupied by commercial beekeepers has been refused. These actions have had a surprising effect. When newcomers are given to understand they cannot crowd their way in they are all the more desirous of coming in. They seek this new protection, slight as it is. The actual result has been that beekeepers wishing to move outfits into Montana have sought out unused territory of value and are putting it into production. Far from being a State trade barrier, an unprecedented number of bees have entered and are entering the State. For the period July 1, 1941 to June 30, 1943, the total entries granted or pending are 6,700 colonies, over one-fifth of Montana's bees in 1941. Small as this regulation may seem it has increased Montana's beekeeping industry and avoided the abuses of overstocking. What the policy will be when the frontier disappears we cannot predict though that time is not far away. Nor do we know whether the Montana regulation is a step in the ultimate control of beekeeping territory on a priority basis. Though it has achieved a result which we believe to be highly satisfactory, it has not been easy to administer.

Another opportunity to utilize Montana's honey resources receives little attention. There are many spots where it is not practicable for commercial beekeepers to operate because of the distances to be traveled and the small productivity of the areas. Some avocational and amateur beekeepers have been remarkably successful in these small geographically isolated localities where they live. The ranks of the avocational one-apiary beekeeper could be swelled many-fold. There is no transportation problem, the territory supports small apiaries well, and if the crop should fail the operator is not dependent on it for a livelihood.

At the same time it should be noted that practically no line of agricultural endeavor has more people who dabble at it more or less unsuccessfully. The success of the amateur beekeeper is directly proportioned to his knowledge and skill in managing bees, and the average amateur beekeeper is not a successful one. Indeed, the actual experience of many an amateur is in shaking a swarm off a bush so it may enter a box. Sometimes the entire knowledge of apiary management is included in shaking a bush. The crop may not be harvested at all and the hive never opened from the time the inspector visits one year until he visits again the next year.

The answer to this problem is an active extension program. Perhaps the most potent extension tool is the actual inspection of apiaries. When the owner is indifferent nothing is achieved beyond actual inspection. But personal contact arouses interest and leads to the solution of problems. Hundreds of bulletins, lists of literature, and supply catalogues have been circulated by personal contact and by mail.

The last spring short course in Flathead County, called by Mr. Leonard Eliason, County Agent, seemed to be quite successful. An average number of ten persons attended four three-hour meetings on consecutive days. Small attendance was compensated for by the interest and enthusiasm of the group. Nowhere else in the State is amateur beekeeping conducted on such a high level of success as in the vicinity of Whitefish. Here amateur beekeeping reflects the results of the short course and the friendly personal influence of one skillful beekeeper. Short courses may show good results in areas where the population is of sufficient density to yield an interested group. But in many sparsely settled isolated areas distance is a controlling factor. When funds and organization permit a more active extension program a correspondence course or radio lecture series would serve a useful purpose where short courses would prove impractical. Present policy has been to focus as much time and attention as possible on the problem of disease control.

BEEKEEPING AND THE WAR EFFORT

Beekeeping occupies a rather significant though somewhat obscure place in Montana's agriculture. In the products, honey and beeswax, we find an essential food and an extremely critical war material. Honey exists as a luxury in minds of many individuals. But honey is sugar, or more exactly, a water solution of natural sugars. It displaces an equivalent amount of granulated sugar in the diet. It behaves as a sugar supplement in the market. Sugar shortages created a honey boom during World War I and the story has been repeated in 1942. Limited shipping has cut off our imports of beeswax as well as sugar. During normal times we import half of the beeswax we consume. Domestic production must now supply the entire load. The demands for beeswax for ammunition grease, finishes, waxes, polishes, leather dressings, machine patterns, pharmaceuticals, dental impressions, must and will be met; demands for modeling, cosmetics, candles and other industrial uses probably will not be met.

Still the most important contribution of bees is not that of honey and wax. The production of fruits, certain vegetables, leguminous forage crop seed is largely dependent on the services of honey bees in the pollination of blossoms. For example, studies by the Montana Agricultural Experiment Station on sweet cherries in Lake County showed that orchards where bees were provided had a blossom set two and one-half times that of orchards farthest distant from bees. By flower visitation bees have entered the production lines of fruits, vegetables, dairy products, meats, leather, and wool, and thus have taken an essential place in a balanced agriculture.

In view of the war effort the U. S. Department of Agriculture called for as large an increase as possible in the production of honey and wax in 1942, and increased cooperation with other agricultural producers who need the pollination services of bees. With this recommendation came the warning that beekeeping is a skilled profession; and, though now is as good a time as any to learn it, amateurs without experience cannot expect to jump in with borrowed capital and make a commercial success of it. This recommendation together with higher prices and War Production Board quotas and priority ratings has resulted in increasing commercial operations by about 20 per cent in 1942, with a proportionate increase in production. Due to irregularities of the weather over the country as a whole, Montana is one of the few states that showed an actual increase in production in 1942. This was achieved by the expansion of existing outfits and also the movement of approximately 2500 colonies into the State. The policy of permitting movement of bee colonies from other states to unused beekeeping territory is increasing the pollination service to legume crops in those areas.

The repercussions of the war on the beekeeping industry have been and will be increasingly felt. Existing machinery and equipment in honey plants have been on the whole adequate. One exception is that higher prices and increased demand make it profitable to pay much more attention to wax production. Many outfits are inadequately equipped for wax handling and wax presses are no longer available. Rubber truck tires will be increasingly critical material. Modern commercial bee culture is based on motor truck transportation from out-apiaries to warehouse and back. Constant use during the season and the margin of profit makes it very impractical to attempt to satisfy this need with commercial vehicles and common carriers. The real shortage will be felt in 1943 and 1944 as present rolling stock wears out. Tires will be absolutely essential to maintain production. The labor shortage has become critical to the point where labor is the controlling factor in maintenance of production. Many outfits were expanded this year without increasing the number of hired helpers. Some of those workers were deferred from the Armed Forces only for the current season. In several cases the owners have planned killing their bees and liquidating their assets in preparation to induction in the Armed Forces. Women and 'teen-age boys are being used with considerable success in extracting plants and shops. But the work in the apiary requires strong backs. Operators are in a quandary over what proportion of their bees should be killed off this fall. If more bees are wintered than they will have labor to handle next year, those bees plus the honey they consume over winter may represent considerable loss. The recent Selective

Service System ruling that the profession of beekeeper be classed as one of the critical agricultural occupations may alleviate the situation and allow the maintenance of present production levels.

The picture is not entirely black. Price control of extracted honey and wax has been a source of confusion, but beekeepers have willingly accepted the principle of price control. Present ceilings allow them to show a reasonable profit on the books for the first time in many years. With this salvation from financial uncertainty and the abundant recognition of the place of bees in our common way of life, the beekeeper deserves and now has a portion of his reward for persistence and service during the lean years of the last depression.

INDEX

Page

INTRODUCTION 3

MAJOR INSECT CONTROL PROBLEMS 4
Grasshopper Control, 1941-42 4
Outlook for 1943 10
Mormon Cricket Control, 1941-42 11
Stored Grain Insects 13

OTHER IMPORTANT INSECT PESTS, 1941-42 14
New Introducted Livestock Pests 14
Primary Screw worm 14
Spinose ear tick 15

Miscellaneous Records and Observations 17
Say's stinkbug 17
Corn leaf aphid 17
Potato and tomato psyllid 17
Red-humped apple caterpillar 18
Diamond back moth 18
Sugar beet webworm 19
Spruce budworm 19
Army cutworm 19
Pale western cutworm 19
Corn earworm 20
Raspbery root or crown borer 20
Raspberry fruitworms 20
Sweet clover weevil 21
Pea weevil 22
Bean weevil 23
Plum gouger 23
Plum curculio 23
Seed-corn maggot 24
Mink maggots 25
Cabbage maggot 25
Wheat stem sawfly 26
Earwigs 26

BIENNIAL REPORT OF THE MONTANA STATE APIARIST, 1942 26
Beekeeping Industry in Montana 26
Disease Control 28
Utilization of Resources 31
Beekeeping and the War Effort 33